DEPARTMENT OF DEFENSE

MILITARILY CRITICAL TECHNOLOGIES

PART III: DEVELOPING CRITICAL TECHNOLOGIES

SECTION 5: CHEMICAL TECHNOLOGY

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SECTION 5—CHEMICAL TECHNOLOGY

Scope

Highlights

- Chemical weapons in the hands of rogue states and terrorist groups will remain a threat to U.S. national security.
- The United States will need to keep abreast of potential new agents and dissemination technologies to defend against their use.
- Full dimensional protection calls for new sensors that "…will be deployed to detect chemical or biological attack at great ranges and provide warning to specific units that may be affected."
- Obscurants offer adversaries methods of defeating and/or degrading precision weapon technology.

OVERVIEW

This section addresses technologies related to the use of toxic chemicals, including the production of chemical agents and their dissemination; defense against chemical agents; and methods to detect, identify, and provide warning of their use. Also included are obscurants, that is, materials that limit or prevent reconnaissance, surveillance, target acquisition, and weapon guidance. Energetic materials (explosives and propellants) are in addressed in Section 2, Armaments and Energetic Materials.

RATIONALE

The Chemical Weapons Convention (CWC) is now in effect and supported by a majority of nations of the world. Since further development of chemical agents is banned by this treaty, the supposition must be that any advances in chemical agents will occur as the results of efforts by rogue states (e.g., Libya, North Korea, and Iraq) or extra-national groups such as the Aum Shinrikyo, which was responsible for the Japanese subway attack in 1995. Unfortunately, the Information Age has made available, and will continue to provide, the wherewithal for such entities to be dangerous in the context both of national defense and in the use of chemical warfare for terrorism.

Although the United States has forsworn the use of chemical weapons (CW), it must be alert to new technological developments that will enable an adversary to employ them. *Joint Vision 2010* describes the four operational concepts that will be developed for the future: dominant maneuver, precision engagement, full-dimensional protection, and focused logistics. It is clear that U.S. forces must be prepared to wage war in an environment that includes the use of weapons of mass destruction (WMD). In addition, the U.S. military must be able to assist in the response to the use of toxic chemicals against domestic targets.

Operation Desert Storm has shown that obscurants, both natural and man-made, can be a force multiplier if properly employed. Current obscurants can be effective in the visible through the far-infrared wavelengths. Newer obscurants will be effective from the nanometer through the 1-m wavelength of the electromagnetic spectrum.

TECHNOLOGY ASSESSMENT

As technology flows to less-developed countries, its use for military as well as peaceful purposes is inevitable. Information on the technology used to produce toxic chemicals for use in chemical weapons is available in the open literature. Some of the classic chemical agents date back over 150 years. Some of the nerve agents require production steps that are more difficult but still within the reach of determined proliferators.

Because of the potential use of CW on the battlefield, many nations are seeking technology to detect, defend, and defeat CW. Another concern is the impact on national security of toxic chemical use by terrorist organizations. Efforts are aimed at positive identification of chemical agents in time to avoid contamination.

WORLDWIDE TECHNOLOGY ASSESSMENT

Any country with a chemical industry has the capability to produce toxic chemical agents. Figure 5.0-1 shows capability, not intent. Countries that have not become a party to the CWC bear close scrutiny. These include Iraq, North Korea, Libya, and Syria. Nations that have signed could well abrogate their commitments under the CWC. Further, it is recognized that research and development of chemical weapons, while once essentially limited to nation-states, is now within the capabilities of extra-national groups that owe no allegiance to causes other than their own.

Any country with a chemical industry has the capability to manufacture man-made obscurants.

Country	Sec. 5.1 Defense Systems	Sec. 5.2 Dissemination and Dispersion	Sec. 5.3 Material Production	Sec. 5.4 Detection, Warning, and Identification	Sec. 5.5 Obscurants
Australia	●●●●	●●●●	●●●●	●●●●	●●
Austria	●●●●	●●●●	●●●●	●●●●	●●●
Bulgaria	●●	●●	●●	●●	●●
Canada	●●●●	●●●●	●●●●	●●●●	●●●
China	●●	●●●●	●●●●	●●●	●●●●
Czech Republic	●●	●●●●	●●●	●●●●	●●
Denmark	●●●●	●●●●	●●●●	●●●●	●●●
Egypt	●●	●●●	●●●	●●	●●●
Finland	●●●●	●●●●	●●●●	●●●●	●●
France	●●●●	●●●●	●●●●	●●●●	●●●●
Germany	●●●●	●●●●	●●●●	●●●●	●●●●
Hungary	●●●●	●●	●●●	●●●●	●●
India	●●	●●	●●●●	●●	●●
Iran	●●	●●	●●●	●●	●●●
Iraq	●●	●●	●●●	●●	●●
Israel	●●●●	●●●●	●●●●	●●●●	●●●
Italy	●●●●	●●●●	●●●●	●●●●	●●
Japan	●●●	●●●	●●●●	●●●	●●●●
Libya	●●	●●	●●	●●	●●
Netherlands	●●●●	●●●●	●●●●	●●●●	●●
North Korea	●●●	●●	●●	●●	●●●
Norway	●●●●	●●●●	●●●●	●●●●	●●●
Pakistan	●●	●●	●●	●●	●●
Poland	●●	●●	●●●	●●	●●●
Russia	●●●●	●●●●	●●●●	●●●●	●●●●
Serbia	●●●	●●●	●●●	●●	●●
Slovak Republic	●●●●	●●●●	●●●	●●●●	●●
South Africa	●●●●	●●●	●●●●	●●●●	●●●
South Korea	●●●●	●●●●	●●●●	●●●●	●●●
Spain	●●●●	●●●●	●●●●	●●●●	●●
Sweden	●●●●	●●●●	●●●●	●●●●	●●●
Switzerland	●●●●	●●●●	●●●●	●●●●	●●●
Syria	●●	●●	●●●	●●	●●●
UK	●●●●	●●●●	●●●●	●●●●	●●●●
United States	●●●●	●●●●	●●●●	●●●●	●●●●

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Figure 5.0-1. Chemical Technology WTA Summary

SECTION 5.1—CHEMICAL DEFENSE SYSTEMS

Highlights
• Capability to operate in a chemically contaminated environment is an important component of full-dimensional protection.
• Efforts to make protective clothing more wearable will reduce the degradation of operational efficiency.
• Decontamination of people and equipment is necessary to prevent continued exposure to toxic chemicals.
• Medical advances may provide relief from the effects of chemical agents.

OVERVIEW

Defense has been the classic counter to the development of new chemical agents and weapons. As the agents have evolved to greater potencies with various ways of entering the body, individual protection, collective protection (protection for groups of individuals), and decontamination technologies have kept pace. Growth in defensive technology, however, has usually been incremental with no major breakthroughs. For example, the mask used today, while greatly improved for protection and comfort, still uses activated charcoal technology first developed in World War I. Moreover, the limits imposed by time and comfort are still the main problems of individual protection. Individual protection of civilians has been complicated by an insistence upon total protection, which leads to decreased comfort and thus severely limits wear time. Decontamination has likewise been complicated by a perceived necessity for total decontamination, coupled with the introduction of important equipment (e.g., electronics) that could be destroyed by current decontaminants.

Military operations considered here include combat operations where chemical agents have been introduced as part of the engagement or where the potential for the use of such agents against U.S. troops exists. Possible employment by extra-national terrorist organizations in urban environments and against domestic "soft targets" are included. In the latter situations, Regular Army, Reserve Units, National Guard Units, or some combination would be expected to assist or augment civil authority.

The following are the principal development issues in this area:

- Improvements in wearability of protective clothing will continue to be a major issue. There is a conflict between the need for encapsulation and impermeability to agents (liquids and vapors) and the need for ventilation and heat stress relief. Current procedures involve either addition of significant weight for climate control or reduced impermeability.
- Permissible times for completely encapsulated personnel need to be increased significantly. Current doctrine in the civil environment when responding to a scene where there is a probable release of an unknown chemical agent (or a known nerve or mustard agent) calls for complete encapsulation of personnel together with a self-contained breathing apparatus. Using current equipment with normal donning and cleanup times, actual time on scene tends to be less than a half hour. In many situations this is not enough time for identification of the agents employed, let alone rescue and clean-up. Protective garments tend to impede coordination and restrict vision when moving and manipulating equipment. There is a similar conflict between complete protection in what may well be an oxygen-poor closed space and the ability to perform necessary tasks.
- The ability to provide medical prophylaxis against many types of chemical agents and to reduce protection requirements would be of value in many environments. A degree of prophylaxis for front-line troops was attempted during the Gulf War. The results are understood to be mixed. Improved prophylactic measures would permit more effective operations against rogue nations in situations where the use of chemical agents against U.S. or Allied troops is possible.

- The development of a nonaqueous decontamination procedure for water-sensitive devices to permit their continued use would greatly enhance continuity of military operations. As we become more dependent on such sophisticated equipment, we become more susceptible to events that limit or destroy its usefulness.

Chemical defense has experienced evolutionary rather than revolutionary change. New materials technology is a possible area where breakthroughs might occur. Since defensive technologies must be applied to large numbers of personnel and diverse situations, this technology must provide economic as well as technological advances. A number of advances are expected:

- Improved materials for suits and masks will resut in lighter protective gear that offers improved comfort and protection.
- Miniaturization of self-contained environmental systems with improved cooling will provide significant reduction in heat stress of protective clothing. At the same time, advanced materials will increase durability and protection against degradation from perspiration. Nanotechnologies hold great promise in this area.
- Medical advances will result in long-term prophylaxis against cholinesterase poisoning and other agent effects for exposures equivalent to several lethal doses.
- Small, efficient, and lightweight oxygen-regeneration devices will be developed to reduce the amount of air to be supplied from bottles and permit extended wear of self-contained breathing apparatus. Concurrent material developments will lead to improved ergonomics, as well as reduced cost, for fully encapsulated suits.
- Nonaqueous techniques will be developed for decontamination of electronic equipment and other materials sensitive to current procedures.
- Combined filter/oxygen supply capabilities with appropriate sensors will be developed for long-term performance in potentially contaminated areas.
- Soldier clothing will be embedded with microelectromechanical systems (MEMS) sensors that warn of chemical hazards.

RATIONALE

Even though the United States has forsworn chemical weapons, our military forces must be prepared to fight an adversary armed with them. Current protective gear dramatically reduces operating efficiency. *Joint Vision 2010* calls for increased individual and collective protection. It also points out that this protection, along with joint restoration capability from the effects of weapons of mass destruction, is a key element for achieving full-dimensional protection—one of the four operational concepts for future warfighting.

The Joint Warfighting Science and Technology Plan enumerates the key operational capabilities in chemical and biological (CB) warfare defense and protection:

- Contamination avoidance, including the ability to detect, identify, and warn of CB attacks. (That is, DIW: detection, identification, warning.)
- Protection, encompassing individual, collective, and medical protection.
- Decontamination.

Figure 5.1-1 illustrates the CB defense concept. The requirements for force protection on the battlefield, shipboard, and at aerial ports of debarkation (APODs) and sea ports of debarkation (SPODs) are shown.

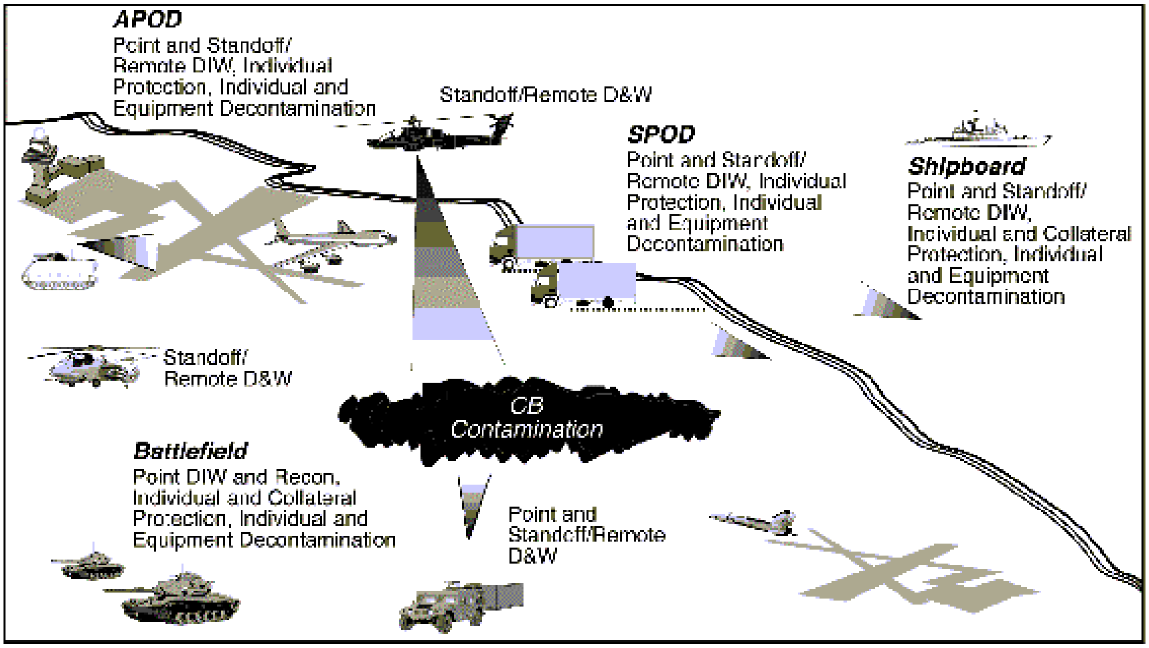

Figure 5.1-1. CB Defense Concept

The key operational capability subelements of force protection are individual protection, collective protection, and medical protection.

The goals of individual protection technology efforts are to (1) improve protection against current threats and add protection against future threats, (2) minimize mission degradation by reducing the impact of the use of individual protection on the warfighter's performance, and (3) reduce logistics burden. The key components of individual protection are ocular/respiratory protection and percutaneous protection. Both components support general warfighter requirements such as the Army's Land Warrior Program, as well as specialized applications for the Navy and Air Force. Advanced filtration technologies to reduce breathing resistance and selectively agent-impermeable membranes to increase uniform comfort will reduce individual performance degradation.

The collective protection technology base efforts seek to maintain protection against current threats and add protection against future threats. At the same time, collective protection technology efforts seek to reduce logistical burdens through the development of improved filter materials with longer usable lifetimes. Collective protection efforts focus on (1) improvements to current reactive-adsorptive materials; (2) advanced nonreactive filtration processes; (3) advanced reactive filtration; (4) regenerable filtration processes for nuclear, biological, and chemical (NBC) protection of military vehicles, aircraft, ships, shelters, and buildings; and (5) reduced logistics burden.

Medical protection consists of three primary functions: (1) pre-exposure preventive measures, (2) diagnosis, and (3) post-exposure treatment. These functions are applied to defense against both chemical and biological threats. Technology efforts will provide a number of medical products for preventing illness or personnel degradation when percutaneous or aerosol CB agents are used on the battlefield. For personnel exposed to these agents, a number of initiatives will seek to ameliorate or preclude the effects of inhaled or percutaneous chemical agents or provide relief from the symptoms of biological agents. Current technologies provide only partial protection against a number of percutaneous or inhaled chemical agents, and only a limited number of vaccines are available against biological agents. Some specific treatments are available for exposure to a limited number of biological agents. Before effective treatment can be applied, the causative chemical or biological agent must be identified, at least by type.

Decontamination is defined as the process of removing or neutralizing a surface hazard resulting from a chemical or biological agent attack. The objective of decontamination technology efforts is to develop methods that are effective, are environmentally safe, react to neutralize chemical agents or disinfect biological agents, and do not degrade the operational effectiveness of the surface or equipment being decontaminated. Current decontamination materials are caustic and rely heavily on water. Moreover, current methods for decontamination cannot be used to decontaminate critical areas at fixed-site facilities, such as seaports or airports, the interiors of sea or air transport vehicles, or sensitive equipment, such as electronics and avionics. Critical studies are needed to define the decontamination technology issues that must be addressed as part of the national global force projection and our ability to simultaneously deploy in two potentially contaminated major theaters of war.

WORLDWIDE TECHNOLOGY ASSESSMENT

A number of countries are developing protective clothing and several produce collective protection systems. At the present time, most customers for such items are military forces. Civilian agencies are procuring commercially developed protection for "first responders" who might come in contact with toxic chemicals resulting from a chemical accident or a terrorist attack.

- **Bulgaria** manufactures a wide range of NBC protective equipment.
- **China** has a thriving NBC defense industry, which supplies the full range of equipment.
- The **Czech Republic** maintains a robust and capable NBC defense industry; its armed forces are well equipped and trained in NBC defense.
- **France** is one of the largest suppliers of NBC defense equipment, especially to Africa and the Middle East. A number of countries in the Middle East—Kuwait, Oman, Qatar, and Saudi Arabia—are actively seeking better NBC defense equipment for their armed forces and civilian population.
- **Germany** is one of the best equipped and trained North Atlantic Treaty Organization (NATO) members in NBC defense.
- **India** relies heavily on the import of NBC protection.
- Before the Gulf War, **Iraq** had begun to develop its own NBC defense industry, making protective suits and masks.
- **Israel** has a sophisticated NBC defense industry, which is particularly strong in the provision of protection for civilians of all ages as well as for its armed forces.
- **The Netherlands** has a considerable research effort underway in NBC defense measures, particularly by TNO Laboratories. Its armed forces are well equipped and trained.
- **Pakistan** has shown considerable interest in the acquisition of NBC defense technology.
- **Poland's** industry provides masks and decontamination facilities.
- **Romania's** industry makes a range of NBC equipment as does **Serbia's** (including protective clothing and masks).
- **Russia** produces a wide array of chemical defense equipment
- **Switzerland** has a well-developed NBC defense sector offering a wide range of protection and contamination control equipment.
- The **United Kingdom** has a comprehensive NBC defense posture, which is actively maintained and expected to continue. In 1994 the UK formed a battalion-size NBC Reconnaissance Regiment that provides detection and decontamination capabilities for the army. The UK is a key exporter of the full range of NBC defense equipment, expertise, and training.

Country	Individual Protection	Collective Protection	Decontamination	Medical Protection
Bulgaria	●●	●●	●●●	●●
Canada	●●●●	●●●●	●●●●	●●●●
China	●●●	●●	●●●	●●●
Czech Republic	●●●	●●●●	●●●●	●●●●
Egypt	●●●	●●	●●	●●
Finland	●●●	●●●●	●●	●●●●
France	●●●●	●●●●	●●●●	●●●●
Germany	●●●●	●●●●	●●●●	●●●●
Hungary	●●●	●●●●	●●●●	●●●●
Iran	●●	●●	●●	●●
Iraq	●●	●●	●●	●●
Israel	●●●●	●●●●	●●	●●●●
Italy	●●●●	●●●●	●●●●	●●●●
Japan	●●●	●●●	●●	●●●
Libya	●●	●●	●	●●
Netherlands	●●●●	●●●●	●●	●●●●
North Korea	●●	●●●	●	●●●
Pakistan	●●	●●	●●	●●
Poland	●●●	●●	●●	●●
Russia	●●●●	●●●●	●●●●	●●●●
Serbia	●●●	●●●	●●●	●●
Slovak Republic	●●●●	●●●●	●●●●	●●●●
South Africa	●●●●	●●●●	●●●	●●●●
South Korea	●●●●	●●●●	●●	●●●●
Sweden	●●●●	●●●●	●●●	●●●●
Switzerland	●●●●	●●●●	●●●	●●●●
Syria	●●	●●	●	●●
UK	●●●●	●●●●	●●●●	●●●●
United States	●●●●	●●●●	●●●●	●●●●

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Figure 5.1-2. Chemical Defense Systems Technology WTA Summary

LIST OF TECHNOLOGY DATA SHEETS
III-5.1. CHEMICAL DEFENSE SYSTEMS

DATA SHEET III-5.1. PRODUCTION AND DESIGN FOR PROTECTIVE CLOTHING

Developing Critical Technology Parameter	Semi-permeable, lightweight material, 20 percent lighter than the battle dress over-garment material system. It will allow selective permeation of moisture while preventing the passage of common vesicant agents, provide protection against penetration by toxic agents in aerosolized form, and provide at least the current level of protection against toxic vapors and liquids.
Critical Materials	Semipermeable membranes; polymers.
Unique Test, Production, Inspection Equipment	Simulated agents; particle-size analysis equipment.
Unique Software	None identified.
Technical Issues	Integration with hood/mask; closure concepts; performance degradation; ability to consume fluids; the development of selectively permeable membranes suitable for all battlefield applications.
Major Commercial Applications	First responders.
Affordability	It will reduce the logistics burden as a result of improved launderability, lighter weight, and reduced volume (less bulky).

RATIONALE

As a result of significantly reduced thermal stress and bulk of uniform, new CB protective clothing will significantly improve performance while in a mission-oriented protective posture (MOPP) . Ultimately, incorporation of CB protection into the standard-duty uniform will provide continuous protection. The key components of individual protection are ocular/respiratory protection and percutaneous protection.

Joint Vision 2010 calls for increased individual protection. This protection is a key element for achieving full-dimensional protection—one of the four operational concepts of future warfighting. The United States has been developing advanced materials that can provide the protection needed and should remain aware of foreign activities in this area, especially in the UK.

WORLDWIDE TECHNOLOGY ASSESSMENT

Bulgaria	●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●	France	●●●●	Germany	●●●●
Hungary	●●	Iran	●	Iraq	●●	Israel	●●●●
Italy	●●●	Japan	●●●	Libya	●	Netherlands	●●●
North Korea	●	Pakistan	●	Poland	●	Russia	●●●●
Serbia	●●●	Slovak Republic	●●	South Africa	●●●	South Korea	●●●
Sweden	●●●	Switzerland	●●●	Syria	●	UK	●●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Many NATO countries have the capability to develop protective clothing. Iraq is beginning to make protective suits and masks and can be expected to continue in the future. Israel is actively developing protection for civilians, as well as military personnel. The Netherlands has considerable research efforts underway, especially by TNO Laboratories. Switzerland has a well-developed NBC defense industry, and the UK's program is comprehensive and expected to continue.

The following companies are actively producing masks:

- ***Germany***
  - Alfred Kaercher GmbH & Co.
- ***Israel***
  - SHALON-Chemical Industries Limited
- ***UK***
  - Avon Technical Products
- ***Russia***
  - ILC Dover Inc.
  - Mine Safety Appliances
  - State factories

Canada and France produce aircrew masks, as well as masks for ground personnel.

Many companies make protective suits:

- ***Austria***
  - J. Blasche Wehrtechnik GmbH
- ***Bulgaria***
  - Kintec
- ***Canada***
  - Acton International, Inc.
- ***France***
  - Bachman SA
  - Manufactures de Vetrement Paul Boye
- ***Germany***
  - Blucker GmbH
  - Alfred Kaercher GmbH & Co.
  - Helsa-Werke
- ***Hungary***
  - Innovatext Rt
- ***Israel***
  - SUPERGUM Limited
- ***Italy***
  - Irvin Aerospace SpA
- ***South Africa***
  - HAZMAT Protective Systems Limited
- ***Sweden***
  - New Pac Safety AB
- ***Switzerland***
  - Saratoga (Wattwil) AG (a joint venture of the Swiss Heberlein Textildrek AG and the German Blucker)
- ***UK***
  - James North & Sons
  - J&S Franklin Limited

DATA SHEET III-5.1. PRODUCTION AND DESIGN FOR COLLECTIVE PROTECTION

Developing Critical Technology Parameter	Protect against 100 percent of current and future threats.
Critical Materials	Impregnated charcoal filters; polyethylene; fluoropolymer/aramid laminate.
Unique Test, Production, Inspection Equipment	Simulated agents.
Unique Software	Airflow models.
Technical Issues	Affordable; deployable/transportable; adaptable to structures.
Major Commercial Applications	First responders.
Affordability	Reduced logistics burden.

RATIONALE

The collective protection technology base efforts seek to maintain protection against current threats and add protection against future threats. At the same time, these efforts seek to reduce logistical burdens through the development of improved filter materials with longer useable lifetimes. Collective protection efforts focus on (1) improvements to current reactive-adsorptive materials; (2) advanced nonreactive filtration processes; (3) advanced reactive filtration; (4) regenerable filtration processes for NBC protection of military vehicles, aircraft, ships, shelters, and buildings; and (5) reduced logistics burden.

Joint Vision 2010 calls for increased collective protection. In the battlefield of the future, it will become increasingly important for groups of forces in vehicles, field medical units, command and control facilities, etc., to be safe from chemical contamination. Collective protection is one of the key elements for achieving full-dimensional protection.

WORLDWIDE TECHNOLOGY ASSESSMENT

Bulgaria	●	Canada	●●	China	●	Finland	●●
France	●●●	Germany	●●●●	Iraq	●	Israel	●●●●
Netherlands	●●●	Russia	●●●	South Africa	●●●	Sweden	●●●
Switzerland	●●●	UK	●●●●	United States	●●●●		

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

A number of countries address the problem of collective protection but not as many as address individual protection. Some companies make parts for shelters (e.g., filtration), while others develop the entire structure. Giat Industries (France) and Hunting Engineering (UK) created a jointly owned subsidiary encompassing the shelters activity at Rennes, which has applications in both military and civil fields.

Other companies developing collective protection systems/components include the following:

- ***Belgium***
  - Air Filtration
- ***Finland***
  - Temet Oy
- ***France***
  - SP Defense (in addition to Giat Industries)

- ***Germany***
  - Albert Kaercher GmbH & Co.
- ***Israel***
  - SHALON Chemical Industries Limited
- ***UK***
  - AEA Technology plc
  - Howden Aircontrol Limited
  - MDH Limited
- ***United States***
  - Lockheed Martin Librascope
  - Allied Signal Aerospace
  - IDL Defense
  - ILC Dover

DATA SHEET III-5.1. MEDICAL PROTECTIVE TECHNOLOGIES

Developing Critical Technology Parameter	Development of practical prophylaxis for entire classes of chemical agents.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	None identified.
Technical Issues	Efficacy of vaccine; efficacy of prophylaxis; pre- vs. post-exposure treatment; understanding agent effects on physiology.
Major Commercial Applications	First responders; hospitals for diagnosis and treatment of civil casualties.
Affordability	Not an issue.

RATIONALE

Personnel must be able to perform their missions effectively. Casualties must be reduced and forces reconstituted. Medical protection will serve three primary functions: (1) pre-exposure preventive measures, (2) diagnosis, and (3) post-exposure treatment. These functions are applied to defense against both chemical and biological threats. Technology efforts will provide a number of medical products for preventing illness or personnel degradation when percutaneous or aerosol CB agents are used on the battlefield. A number of initiatives will seek to ameliorate or preclude the effects of inhaled or percutaneous chemical agents on exposed personnel. Current technologies provide only partial protection against a number of percutaneous or inhaled chemical agents. Before effective treatment can be applied, the causative chemical agent must be identified, at least by type.

Individual protection is one of the key elements of full-dimensional protection as addressed in *Joint Vision 2010*. Increasingly, medical protection is being developed in addition to the more traditional forms of protection—masks and clothing. By preventing casualties, vaccines and salves will help to negate attacks with toxic chemicals. A strong defense has often been thought to act as deterrent to offensive chemical warfare.

WORLDWIDE TECHNOLOGY ASSESSMENT

Bulgaria	●●	Canada	●●●	China	●●●	Czech Republic	●●●
Denmark	●●	Egypt	●●	Finland	●●●●	France	●●●●
Germany	●●●●	Hungary	●●●	Iran	●	Iraq	●
Israel	●●●●	Italy	●●●	Japan	●●●	Libya	●
Netherlands	●●●	North Korea	●	Norway	●●●●	Russia	●●●●
Slovak Republic	●●●●	South Africa	●●●	South Korea	●●●	Sweden	●●●
Switzerland	●●●	Syria	●	UK	●●●●	United States	●●●●

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Medical protective technologies are developed by the major NBC-related companies throughout the world such as:

- ***France***
  - Giat Industries
- ***Germany***
  - Albert Kaercher GmbH & Co.
  - Aerochem

- ***Israel***
  - SHALON Chemical Industries Limited

Current efforts are usually aimed at treating contaminated personnel. Efforts in the future will be directed at preventing the toxic effects of chemical agents through salves and vaccines.

DATA SHEET III-5.1. REGENERATIVE FILTRATION

Developing Critical Technology Parameter	Need for protection with unlimited capacity to remove CB agents from air streams to generate breathable air.
Critical Materials	Pressure swing absorption (PSA): compressed air from vehicle or alternative source. Temperature swing absorption (TSA): source of heat/energy from vehicle.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Software to detect system malfunction must be developed.
Technical Issues	PSA: removal rate of strongly adsorbed vapors after chemical attack. High energy cost. TSA: Sizing of TSA adsorption beds to prevent penetration of weakly adsorbed threat vapors and allow short (10 min) regeneration cycles. Large energy requirement.
Major Commercial Applications	First responders.
Affordability	Regenerative filters would reduce the logistics burden of filters that must be replaced.

RATIONALE

There is a need for protection with unlimited capacity to remove CB agents from air streams to generate breathable air. As part of full-dimensional protection, collective protection (e.g., in shelters, vehicles, ships, aircraft) must be provided to enable forces to operate in groups in a contamination-free environment. Field hospitals must be protected from contamination. *Joint Vision 2010* calls for increased collective protection, one of the key elements for achieving full-dimensional protection.

Regenerative filtration will reduce the logistics burden by eliminating the need to transport filters. It will also ensure that continuous filtration is provided to troops, thus protecting them from toxic chemicals.

WORLDWIDE TECHNOLOGY ASSESSMENT

Canada	●●●●	Finland	●●●	France	●●●●	Israel	●●●●
Sweden	●●●●	Switzerland	●●●●	UK	●●●●	United States	●●●●

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

The following companies expend a lot of effort in developing filtration products both for the military and commercial uses:

- ***Canada***
  - Racal
- ***Finland***
  - Kemira OY
- ***France***
  - Giat Industries
  - SP Defense
- ***Israel***
  - SHALON-Chemical Industries Limited
- ***Sweden***
  - Floding

- ***Switzerland***
  - Micronel AG
- ***UK***
  - Avon Technical Products

SECTION 5.2—CHEMICAL DISSEMINATION AND DISPERSION

Highlights
• Although there are many technologies for dissemination and dispersion of chemical weapons, new and/or unexpected means may be devised.
• Computer simulations may enable countries to "test" CW clandestinely.
• Advances in meteorological sensors might permit dissemination of CW with maximum effect.

OVERVIEW

The emergence of rogue states and extra-national groups as principal causes of concern over the use of chemical agents changes the nature of the problem. Although traditional weapons systems discussed in Part II, Weapons of Mass Destruction Technologies, remain a factor, smaller numbers of less conventional weapons are expected to constitute the majority of the chemical weapons threat. Developing technologies could assist in the dissemination and dispersion of chemical agents by making current methods more practical and efficient, not necessarily through novel means. Improved spray patterns, the ability to sense meteorological conditions in the target area, and remote control of unmanned systems could enable CW to be used more effectively.

Problems of degradation during storage and materials compatibility, which have been serious concerns in the maintenance of chemical stockpiles in the past, are a small concern if the objective is to make and use the agents in relatively short periods of time. Simple, easily obtained commercial containers (e.g., spray bottles) could be used by extra-national groups to conduct acts of terrorism in cities and attack multiple "soft" targets. Combining simple devices with advances in electronic timing and control makes their use both more dangerous and probable. Primary devices in a terrorist incident appear likely to be small, spray-type munitions, used so that the source remains at least partly covert. Secondary devices aimed at attacking first responders and reducing public confidence in the Government's ability to handle a situation are most likely to be explosive devices, which can release quantities of agent quickly over a broad area. Such devices could easily be disguised as objects normally found in the area. There also is a likelihood that extra-national groups might use a mix of agents to confound the response team.

Improvements in sensing and determining effects of micrometeorology will enhance employment of chemical weapons. Knowledge of micrometeorology would theoretically allow the effective use of unmanned aerial vehicles (UAVs) and cruise and ballistic missile technology for delivery of chemical weapons.

Urban modeling using computational fluid dynamics may be available to accurately predict effects of chemical use in specific urban environments, thus making such use more devastating. Although each model would apply to only a specific scenario, generic modules would allow a standard model to be easily adapted to the site in question.

Solids dispersion technology advances would permit effective employment of both lethal and incapacitating agents.

Dissemination and dispersion of chemical agents is seen as benefiting from the use of currently unconventional insertion techniques (such as UAVs) to achieve desired target effects.

RATIONALE

Rogue states in particular, as well as terrorist groups, will have access to the Global Positioning System (GPS), which would allow them, at low cost, to place a chemical delivery system (e.g., a small, unmanned aircraft) accurately on a predetermined target while avoiding conventional defenses. The microminiaturization of sensors to determine wind speed and direction would permit aligning such a device for maximum effect.

Dissemination and dispersion in the future are more likely to be influenced by enhancements in information systems than advances in munitions. Techniques to disseminate chemical agents more effectively are contingent on sensing of local conditions and knowledge of dispersion patterns.

WORLDWIDE TECHNOLOGY ASSESSMENT

Foreign countries will need to develop or obtain advanced sensors and computer modeling to deliver CW more effectively in a battlefield situation. Integration of these technologies with dissemination and dispersion techniques will be a key factor. Since the United States has renounced chemical weapons and is a party to the CWC, this assessment is based on theoretical capability. So, too, is the capability of other countries that have ratified the CWC and are expected to adhere to their commitments.

Country	Dissemination	Dispersion
Australia	●●●●	●●●●
Bulgaria	●●	●●
Canada	●●●●	●●●●
China	●●●●	●●●●
Czech Republic	●●●●	●●●●
Denmark	●●●●	●●●●
Egypt	●●●	●●●
Finland	●●●●	●●●●
France	●●●●	●●●●
Germany	●●●●	●●●●
Hungary	●●	●●
India	●●	●●
Iran	●●	●●
Iraq	●●	●●
Israel	●●●●	●●●●
Italy	●●●●	●●●●
Japan	●●●	●●●
Libya	●●	●●
Netherlands	●●●●	●●●●
North Korea	●●	●●
Norway	●●●●	●●●●
Pakistan	●●	●●
Poland	●●	●●
Russia	●●●●	●●●●
Serbia	●●●	●●●
Slovak Republic	●●●●	●●●●
South Africa	●●●	●●●
South Korea	●●●●	●●●●
Spain	●●●●	●●●●
Sweden	●●●●	●●●●
Switzerland	●●●●	●●●●
Syria	●●●	●●
UK	●●●●	●●●●
United States	●●●●	●●●●

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Figure 5.2-1. Chemical Dissemination and Dispersion Technology WTA Summary

LIST OF TECHNOLOGY DATA SHEETS
III-5.2. CHEMICAL DISSEMINATION, DISPERSION, AND WEAPONS TESTING

DATA SHEET III-5.2. URBAN MODELING

Developing Critical Technology Parameter	Detailed urban architecture, with generic, interactive, three-dimensional modules capable of being adjusted to a specific scenario.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Image conversion to digital map; interactive virtual reality models; transport prediction codes.
Technical Issues	Computational complexity; unique areas; currency of the model; speed of development. Integration of real-world (e.g., meteorology) conditions. Verification of models.
Major Commercial Applications	Disaster preparedness.
Affordability	Not an issue.

RATIONALE

The potential to wage war in urban areas is increasing. The dispersion of chemical agents on the battlefield is well understood; however, urban architecture changes the pattern that would be expected in the open. Models of urban areas are needed to understand chemical agent distribution and effects in built-up areas. They would not be used by the United States in the context of offensive chemical warfare, which the United States has forsworn, but are extremely helpful in providing full-dimensional protection for our forces. This technology is being developed as part of other applications. The same models, however, could be used by an attacker.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●	Canada	●●●●	China	●●	Czech Republic	●●
Denmark	●●●●	Egypt	●●	Finland	●●●	France	●●●●
Germany	●●●●	Hungary	●●	India	●●●	Iran	●
Iraq	●	Israel	●●●●	Italy	●●●●	Japan	●●●
Libya	●	Netherlands	●●●	North Korea	●	Norway	●●●●
Pakistan	●	Poland	●●	Russia	●●●	South Africa	●●
South Korea	●●●	Sweden	●●●●	Switzerland	●●●●	Syria	●●
UK	●●●●	United States	●●●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

There is a great demand for urban models in commercial as well as military circles. Those countries that have advanced efforts in information technology can be expected to make the most progress in modeling the urban landscape.

DATA SHEET III-5.2. MICROMETEOROLOGY

Developing Critical Technology Parameter	Ability to predict local effects of wind and temperature gradients within 10 m of the surface as they continually change. Ability to make critical measurements that permit continuous predictions.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Interactive virtual reality models; transport prediction codes.
Technical Issues	Development of interactive micrometeorological predictive models and measurement devices that can be used to supply data for forecasting and analysis. Model verification and instrument correlation.
Major Commercial Applications	Disaster preparedness.
Affordability	Not an issue.

RATIONALE

To properly map contamination from chemical attack, it is necessary to know the meteorology of the battlefield where the agent was employed. Micrometeorology will help to defend and control complex areas and define the limits of agent contamination. For the United States, this would not be used in the context of offensive chemical warfare, which the United States has forsworn. It would fall under the categories of force protection and domestic preparedness in *Joint Vision 2010*.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●	Canada	●●●●	China	●●	Czech Republic	●●
Denmark	●●●●	Egypt	●●	Finland	●●●	France	●●●●
Germany	●●●●	Hungary	●●	India	●●●	Iran	●
Iraq	●	Israel	●●●●	Italy	●●●●	Japan	●●●
Libya	●	Netherlands	●●●	North Korea	●	Norway	●●●●
Pakistan	●	Poland	●●	Russia	●●●	South Africa	●●
South Korea	●●●	Sweden	●●●●	Switzerland	●●●●	Syria	●●
UK	●●●●	United States	●●●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

This technology is also being developed by commercial and nonmilitary governmental entities. Those countries with the most developed computational capability and information technology will lead the way.

DATA SHEET III-5.2. COMPUTATIONAL FLUID DYNAMICS

Developing Critical Technology Parameter	Ability to predict airflow patterns within and immediately adjacent to structures and to model the interchange between interior and exterior fluid mass transport phenomena.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Interactive virtual reality models; transport prediction codes.
Technical Issues	Development of complex transport phenomena models in modules that can be assembled interactively to model interchange when agent is released indoors or immediate to a building's exterior. Measurement and verification of models and combined model modules.
Major Commercial Applications	Disaster preparedness; pollution abatement.
Affordability	Not an issue.

RATIONALE

This technology is needed to defend against the consequences of indoor agent release or the interior effects of external agent release. It would not be used in the context of offensive chemical warfare, which the United States has forsworn. It would be applied in a number of areas, including urban warfare and domestic preparedness. This technology would assist in force protection as described in *Joint Vision 2010*. The technology is being developed as part of other applications.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●	Canada	●●●●	China	●●	Czech Republic	●●
Denmark	●●●●	Egypt	●●	Finland	●●●	France	●●●●
Germany	●●●●	Hungary	●●	India	●●●	Iran	●
Iraq	●	Israel	●●●●	Italy	●●●●	Japan	●●●
Libya	●	Netherlands	●●●	North Korea	●	Norway	●●●●
Pakistan	●	Poland	●●	Russia	●●●	South Africa	●●
South Korea	●●●	Sweden	●●●●	Switzerland	●●●●	Syria	●●
UK	●●●●	United States	●●●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Pollution control modeling and hazardous materials (HAZMAT) spill modeling are the drivers of this technology. Lessons learned in this application could be applied to military operations, particularly in urban areas.

DATA SHEET III-5.2. ENHANCED DERMAL PENETRATION

Developing Critical Technology Parameter	Techniques for (1) enhancing skin penetration of percutaneously toxic materials so that penetration occurs rapidly (within minutes), (2) penetrating protective masks in physiologically significant amounts and in logistically deliverable quantities, or (3) circumvention of the protective mask.
Critical Materials	Penetrating agents, mask-breaking agents.
Unique Test, Production, Inspection Equipment	Effective heavy gas models (i.e., models describing the behavior of gases several times the vapor density of air).
Unique Software	None identified.
Technical Issues	Developing a compound that penetrates and is toxic. (Most materials surveyed that have good penetrant or mask-breaking capability are of only moderate toxicity, most being less toxic than the WWI agent phosgene and thus virtually impossible to employ logistically.)
Major Commercial Applications	None identified.
Affordability	Not an issue.

RATIONALE

Chemical agents would be selected and/or disseminated in such a manner as to circumvent the protective mask and protective clothing. The desire for a means of circumventing the protective mask has existed since the introduction in WW I of charcoal filters that greatly reduced the efficacy of the choking gases. In an effort to bypass the mask and re-establish efficient chemical warfare, the German Army introduced both arsenicals (e.g., vomiting agents) and sulfur mustards. The threat of mustard and its counterparts, as well as the later advent of percutaneously acting nerve agents, resulted in the development of protective clothing. In the 1960's and 1970's programs were conducted to use agents of intermediate volatility or of high airborne percutaneous toxicity to penetrate protective clothing. In the 1980's, mask breakers that would not be retained on charcoal filters were examined by both western and communist powers. In none of these instances were there reports of notable success. Rogue nations and extra-national groups, which are not bound by the treaties and conventions of the world's states (or have chosen to ignore them), might employ clothing penetrants such as toxic fragmentation devices or tailored filter penetrants (including emetics and lethal/emetic combinations). These could be used as means of penetrating or defeating protective clothing.

WORLDWIDE TECHNOLOGY ASSESSMENT

China	●	Iran	●●	Iraq	●●	Libya	●●
North Korea	●●	Syria	●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Although specific work being done is difficult to assess, rogue nations or extra-national groups could be expected to put effort into R&D.

DATA SHEET III-5.2. NONTRADITIONAL INSERTIONS

Developing Critical Technology Parameter	Use of nonconventional delivery means such as UAVs to overtly or covertly disseminate chemicals that attack other than the "traditional" neurotransmitter sites.
Critical Materials	Materials that block alternative neurotransmitters and/or cause disruption in vital body functions.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Map of human genome; neurotransmitter models for newly discovered/defined substances.
Technical Issues	Identifying other than the known neurotransmitters that have functions whose disruption will have serious consequences for the human body.
Major Commercial Applications	None identified.
Affordability	Not an issue.

RATIONALE

Development by rogue nations or by extra-national terrorist groups whose only rules are "there are no rules" is likely. Although the United States has forsworn the use of chemical munitions, rogue nations and extra-national groups may take advantage of legitimate advances in science and technology to introduce unique applications of chemical warfare.

WORLDWIDE TECHNOLOGY ASSESSMENT

Iran	●	Iraq	●	Libya	●	North Korea	●
Syria	●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Although specific work being done is difficult to assess, rogue nations or extra-national groups could be expected to put effort into R&D.

DATA SHEET III-5.2. SOLIDS DISPERSION

Developing Critical Technology Parameter	Techniques for effective dissemination and dispersion of solid particulates efficiently in the inhalable size range (0.5–5 µm).
Critical Materials	Possibly deagglomerants.
Unique Test, Production, Inspection Equipment	Effective and reproducible measurement technology for aerodynamic particle size of dispersed solid particulates.
Unique Software	Particulate dispersion models for nonspherical solid aerosols.
Technical Issues	Universal techniques for deagglomeration and dispersion of solid aerosols may not be achievable.
Major Commercial Applications	Dispersion of agricultural and pesticide products.
Affordability	Not an issue.

RATIONALE

The majority of incapacitants and probably those materials affecting neurotransmitters will exist normally as particulate solids. Solids naturally tend to agglomerate and are difficult to effectively disseminate as inhalable aerosols. The United States has forsworn chemical agents; however, rogue nations and extra-national groups may attempt to improve dissemination and dispersion of newly developed materials.

Solids dispersion is an industrial (and a pharmaceutical) problem as well as a potential chemical warfare problem. There will continue to be considerable research and development for legitimate purposes.

WORLDWIDE TECHNOLOGY ASSESSMENT

Iran	●	Iraq	●	Libya	●	North Korea	●
Syria	●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Although specific work being done is difficult to assess, rogue nations or extra-national groups could be expected to put effort into R&D. A significant amount of work has been accomplished commercially in solid pesticides.

SECTION 5.3—CHEMICAL MATERIAL PRODUCTION

Highlights

- Although production technologies for chemical agents are widely known, the use of combinatorial chemistry in conjunction with new screening methods could lead to the discovery of toxic chemicals unknown at present.
- Chemical agents can be tailored to affect target populations (lethal and nonlethal).

OVERVIEW

This subsection addresses the production of toxic chemicals for use in war. Although a majority of the nations in the world is expected to abide by the ban of chemical weapons embodied in the CWC, some may not, and others will not become parties to the convention. Non-state groups also may develop CW in an attempt to further their goals.

The following are advances that might occur, even with the more limited resources of the rogue states or extra-national groups. The most potent lethal chemical agents discovered to date are those which directly influence neurotransmitters in one way or another. Neurotransmitters are chemical substances that transmit nerve impulses across the synapses (junctions) between certain types of nerve cells. Although a large number of them have been identified, their precise role and the mechanisms of their actions have been determined for only a few.

The principal chemical warfare agents postulated and/or produced since World War II have affected the actions of the neurotransmitter acetylcholine by inactivating the enzyme acetylcholinesterase and thereby interfering with the regular sequence of nerve impulses. Tabun (GA), produced by the Germans in WW II, and sarin (GB) and soman (GD), synthesized and readied for production (but fortunately never produced by the Germans), are in this category. Similarly, the GB and chemical nerve agent (VX) produced and stockpiled by the United States and GB, GD, and a variant of VX produced and stockpiled by the former Soviet Union were anticholinesterase agents. In the Iran-Iraq War, GA and GB/GF nerve agents were used; GB/GF was prepared (although not used) by the Iraqis in the Gulf War. The Aum Shinrikyo employed GB in their terrorist attacks. Both rogue states and extra-national groups are thought to have experimented with VX.

VX and its analogues are among the most toxic organophosphorus poisons, and there is thought in some areas that these compounds represent close to the practical limits of toxicity for the anticholinesterase agents. Another neurotransmitter, gamma-aminobutyric acid (GABA), used for channel blocking has probably reached its maximum efficacy.

"New" agents are less likely to be the organophosphorus agents of today, but rather combinations which block multiple sites or which block neurotransmitter functions not understood at present. Neuroscientists are currently unraveling the functions of the other neurotransmitters. It is virtually certain that this information will be in the public domain and thus be available to the undesirable nations or groups to tailor different, more effective agents. It is anticipated that knowledge of the biochemical actions of the neurotransmitters may enable tailoring of agents that are potentially more dangerous as well as more difficult to counter.

Several types of toxins are among the most toxic nonliving substances known. Toxins have high molecular weights and the full structural conformation of many of them has not been fully determined. Botulinus toxin, a mixture of eight 135 to 170 kD (kilodaltons) proteins, acts by inhibiting the release of acetylcholine in a cell. Which of the proteins responsible for the inhibition is not known for certain. During the coming decade the ability to map the proteins' molecular structures may provide the ability to create relatively simple "molecular fragments" that could be readily incorporated in larger molecules and would exhibit the essential toxic properties of the toxin.

The mapping of the human genome (and the subsequent public release of this information in the next few years) could provide the unscrupulous with useful information needed for designing genetically tailored chemical agents that would attack specific sites in the body or selectively attack specific individuals or groups of individuals of a common genetic type.

Despite the prohibitions under the CWC, the wording and definitions regarding incapacitating agents remain necessarily vague because they encompass specific biological effects, as well as a multitude of commercial pharmaceuticals. History seems to show a recurring impetus to revert to more “humane” forms of warfare. Toward this end, it is believed possible that forms of nonlethal but physically incapacitating agents may be developed and used. Particularly interesting would be materials created for “police” efforts internal to advanced nations that become known and/or available to extra-national groups or rogue states. Among the conceivable incapacitating agents are those that could result in overt or covert mood altering, the modification of hormonal systems, or the interference with bio-molecular kinetics.

Given the probable world situation in the next 5–10 years, it is anticipated that chemical agent production even in the rogue states may be covert and may represent essentially bench-scale processes that can be easily concealed. Contrary to popular belief, neither the United States nor the Soviet Russian production facilities for their respective stockpiles were ever what could be construed as large scale. As a result of ongoing improvements in process control and automated processes, a high degree of automation would be expected for these future production facilities. They would likely be tailored to a “fill just before use” concept and generally difficult to locate.

For agents that attack two or more neurotransmitters or for those intended for attacking genetically defined sites, a pharmaceutical-like manufacture would be expected.

In the realm of terrorism, in addition to the above, it is envisioned that potential “chemical agents” could also result from the use of industrial chemicals against an unprotected civilian population.

RATIONALE

A description of chemical production techniques sufficient for a country/group to produce chemical agents for chemical weapons exists in the open literature. New techniques in combinatorial chemistry might enable a proliferator to synthesize and screen hundreds or even thousands of compounds and discover toxic chemicals previously unknown. It is imperative that the United States stay aware of new technological developments and understand their implications for chemical warfare.

WORLDWIDE TECHNOLOGY ASSESSMENT

Responsible countries will not engage in the development of new chemical agents; however, to detect their use and protect their people, they must be aware of developments in the field. Rogue states/groups can be expected to turn to any avenue of development, especially one not widely known. Methods of production should not be assumed to be necessarily like those used previously in more conventional chemical production (see Biological Technology, Section 4, for capability in related biological technologies). Figure 5.3-1 indicates the capability of countries, not the *intent*. It is expected that parties to the CWC will honor their commitments and refrain from producing toxic chemicals for weapons.

Country	Material Production
Australia	●●●●
Bulgaria	●●●
Canada	●●●●
China	●●●●
Czech Republic	●●●
Denmark	●●●●
Egypt	●●●
Finland	●●●●
France	●●●●
Germany	●●●●
Hungary	●●●
India	●●●●
Iran	●●
Iraq	●●
Israel	●●●●
Italy	●●●●
Japan	●●●●
Libya	●●
Netherlands	●●●●
North Korea	●●
Norway	●●●●
Pakistan	●●
Poland	●●●
Russia	●●●●
Serbia	●●●
Slovak Republic	●●●
South Africa	●●●●
South Korea	●●●●
Spain	●●●●
Sweden	●●●●
Switzerland	●●●●
Syria	●●●
UK	●●●●
United States	●●●●

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Figure 5.3-1. Chemical Material Production WTA Summary

LIST OF TECHNOLOGY DATA SHEETS
III-5.3. CHEMICAL MATERIAL PRODUCTION

DATA SHEET III-5.3. BIOCHEMICAL MODELING

Developing Critical Technology Parameter	Identify key physiological sites based on knowledge of neurotransmitters and sites in the human genome.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Biomolecular kinetic modeling algorithms.
Technical Issues	Three-dimensional interactive modeling.
Major Commercial Applications	Medical and pharmaceutical.
Affordability	Not an issue.

RATIONALE

Knowledge of the functions and structure of neurotransmitters and the human genome would allow for the modeling and subsequent creation of chemical molecules that would react at selected sites for a wide variety of effects. The information on the human genome and much derivative data is expected to be in the public domain and thus readily accessible to those who would use it for other than beneficial purposes. Knowledge of the human genome could theoretically permit a rogue state or extra-national group to “tailor” physiological effects to their desired ends. The United States must understand new technologies so that it can develop defensive measures.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●	Canada	●●●●	China	●●	Czech Republic	●●●
Egypt	●	France	●●●●	Germany	●●●●	Hungary	●●
India	●●	Iran	●	Iraq	●	Israel	●●●
Italy	●●●	Japan	●●●●	Netherlands	●●●●	North Korea	●
Norway	●●●	Poland	●●	Russia	●●●	South Korea	●●●
Sweden	●●●●	Switzerland	●●●●	Syria	●	UK	●●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Sequencing of the human genome is a multilateral, civilian effort. The United States, UK, France, Germany, Switzerland, and Japan are the primary participants. Most of the genome database is available on the World Wide Web, giving any country or group access to the information.

DATA SHEET III-5.3. DESIGNER CHEMISTRY

Developing Critical Technology Parameter	Molecular structures that bind on two or more specific sites and/or molecular structure based upon fragments of toxin structure to take advantage of high potency of the toxin.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Interactive chemical and biochemical modeling.
Technical Issues	Three-dimensional interactive modeling.
Major Commercial Applications	Possible medical and pharmaceutical.
Affordability	Not an issue.

RATIONALE

Toxicity based upon cholinesterase inhibition and/or GABA sites is thought to be close to the maximum possible. For more effective agents, the proliferant would most logically pursue other neurotransmitter sites. Although the United States has forsworn chemical agents, rogue nations and extra-national groups may seek to use developing knowledge of the human genome to design specialized agents that attack other or multiple neuro-transmitter sites. The United States must understand new technologies so that it can develop defensive measures.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●●
Denmark	●●●●	Egypt	●●●	Finland	●●●●	France	●●●●
Germany	●●●●	India	●●●●	Iran	●●	Iraq	●●
Israel	●●●●	Italy	●●●●	Japan	●●●●	Libya	●●
Netherlands	●●●●	North Korea	●●	Norway	●●●●	Pakistan	●●
Poland	●●●	Russia	●●●●	Slovak Republic	●●	South Africa	●●●●
South Korea	●●●●	Spain	●●●●	Sweden	●●●●	Switzerland	●●●●
Syria	●●	UK	●●●●	United States	●●●●		

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Rogue nations and extra-national organizations could be expected to devote effort to creating new types of toxic chemical agents. Combinatorial chemistry allows the screening of thousands of chemical compounds in a short period of time. The same efforts that are used by responsible countries and groups for developing new drugs and medicines could be diverted to nefarious objectives. The assessment above indicates capability to develop new chemical compounds and does not show intent to use these procedures for ill.

DATA SHEET III-5.3. RELATIONAL TOXICOLOGY

Developing Critical Technology Parameter	Using data from the human genome, the physiological effects are tied to a genetic trait so that the agent only affects specific individuals.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Interactive chemical and biochemical modeling.
Technical Issues	Three-dimensional interactive modeling.
Major Commercial Applications	Medical and pharmaceutical.
Affordability	Not an issue.

RATIONALE

Once the human genome is mapped, it will be theoretically possible to attack a specific group of genes that control various functions or are unique to individuals/ethnic groups. This would be the ultimate specific agent, which could be tied to as narrow or broad a genetic definition as desired. The United States and numerous other countries have forsworn the use of CW and would not devote resources to this type of effort. An opposing force could theoretically be attacked, with only limited protection required by the troops dispensing the agent. Information in this area is partially proprietary, although basic information may be in the public domain. The United States must understand new technologies so that it can develop defensive measures.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●●
Denmark	●●●●	Egypt	●●●	Finland	●●●●	France	●●●●
Germany	●●●●	India	●●●●	Iran	●●	Iraq	●●
Israel	●●●●	Italy	●●●●	Japan	●●●●	Libya	●●
Netherlands	●●●●	North Korea	●●	Norway	●●●●	Pakistan	●●
Poland	●●●	Russia	●●●●	Slovak Republic	●●	South Africa	●●●●
South Korea	●●●●	Spain	●●●●	Sweden	●●●●	Switzerland	●●●●
Syria	●●	UK	●●●●	United States	●●●●		

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Rogue nations and extra-national organizations could be expected to pursue this type of capability. It has been reported that Iraq had developed such an agent to be used against Israel, but there has not been any proof that such an agent can be developed. Assessments in the chart indicate capability to do relational toxicology, not the intent to use it for nefarious means.

DATA SHEET III-5.3. BIOREGULATION

Developing Critical Technology Parameter	Development of chemicals which modify hormonal systems or serve as mood-altering agents.
Critical Materials	Specialized drugs with unique hormonal modification properties.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Interactive chemical and biochemical modeling.
Technical Issues	Three-dimensional interactive modeling. Evaluation techniques to assess the efficacy of mood-altering and other nonphysical effects on personnel performance.
Major Commercial Applications	Possible medical and pharmaceutical.
Affordability	Expected to be large, complex, and difficult-to-synthesize molecules and hence rather costly.

RATIONALE

Agents of this type could serve as subtle and possibly covert incapacitating agents used to control the response of large segments of a population. Although the United States has foresworn the use of CW in warfare, such materials might be the products of pharmaceutical research and considered for internal law enforcement purposes. As a corollary, a rogue state or large extra-national group could use commercial (or specially derived) pharmaceuticals to control large segments of the population. The United States must understand new technologies so that it can develop defensive measures.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●●
Denmark	●●●●	Egypt	●●	Finland	●●●●	France	●●●●
Germany	●●●●	India	●●●●	Iran	●●	Iraq	●●
Israel	●●●●	Italy	●●●●	Japan	●●●●	Libya	●●
Netherlands	●●●●	North Korea	●●	Norway	●●●●	Pakistan	●●
Poland	●●●	Russia	●●●●	Slovak Republic	●●	South Africa	●●●●
South Korea	●●●●	Spain	●●●●	Sweden	●●●●	Switzerland	●●●●
Syria	●●	UK	●●●●	United States	●●●●		

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Rogue nations and extra-national organizations could be expected to pursue this type of capability. Assessments in the chart indicate capability to develop bioregulation agents, not the intent to use them for nefarious means.

SECTION 5.4—CHEMICAL DETECTION, WARNING, AND IDENTIFICATION

Highlights

- Sensors that detect chemical attack at great ranges and provide warning to specific military units that may be affected are part of full-dimensional protection.
- Adequate warning may allow forces to avoid contamination.
- Point detectors with significantly improved specificity and sensitivity will allow increased protection for exposed troops and improved capability to avoid localized chemical contamination.

OVERVIEW

This subsection reviews forecast changes to current technology and predicts how these advances might be applied to problems and shortfalls in the detection and identification of chemical agents. The assessment takes into consideration both combat operations and the application of detection technology to terrorist events where the military is likely to be involved.

The range of operations includes actual combat situations where U.S. troops are deployed against a discrete enemy force during actual hostilities or in an international peacekeeping operation. The application of detection and identification also extends to civil operations where an act of suspected chemical terrorism has taken place and military forces have been deployed to provide assistance to local authorities.

The following are the principal issues in the detection arena:

- Improvements in sensitivity to all significant threat agents to permit detection down to or below the respective threshold limit values. In this manner not only could the agents be effectively detected but a “safe” level for removal of protection be determined.
- Improved specificity in agent identification becomes crucial when agents might be employed in an urban or industrial environment. Current detection schemes are more or less fail-safe and yield many false positives, but generally preclude false negatives. This works reasonably well in a battlefield environment, where there are few interfering substances, but can become a major problem where extraneous substances abound. Generally, multiple procedures and comparisons are required for specific identification, which is critical in urban sites where treatment and assured cleanup are dependent on knowledge of the material involved. The complexity and logistics of this task has limited development.
- The inability to conduct tests in open-air conditions with real materials places limits on the realistic evaluation of many sensors, particularly “stand-off” detectors.
- The inability of a sensor to purge previous “sensings” and rapidly be available for additional tests is an operational limitation. The ability to clear sensors almost immediately or to provide an alternative path for sensing would provide a significant improvement in detection operations.
- Remote sensing at low levels is another area where progress is needed. For example, it is currently difficult, if not impossible, to detect terrain or other materials contaminated with a low-volatility substance such as VX without direct contact with the liquid.

Fortunately, the technologies that underlie improved detection and identification have undergone an accelerated development in the last decade, in large degree due to the explosive growth in photonic and electronic technologies and miniaturization. These changes have permitted adaptation of instruments that were in the recent past only suitable for research applications in the laboratory to field applications. These trends are expected to continue, partially as fallout from increased computational capabilities. The sensitivity of instruments has increased at a similar rate.

In the future the following improvements in technology will be realized:

- Sensitivities in technologies applicable to a broad area of substance sensing, such as surface acoustic wave (SAW) technology, will be improved. The result will be economical production of highly sensitive (and relatively small) individual detectors. At present "small" is limited not so much by the SAW crystals themselves but by the size of the peripheral equipment required for proper functioning. Pumps are required to move air samples over the SAW crystals, temperature control is necessary to compensate for drifting frequencies, and trap-and-purge is necessary for realistic specificity (purging requires significant amounts of electrical power or batteries). In addition, the increases in sensitivity necessary have yet to be demonstrated and require further research and development

- Current instruments that have quasi-field capabilities, such as combined gas chromatography-mass spectrometry (GC-MS) and mass spectrometry-mass spectrometry (MS-MS), will be improved and miniaturized to the point where they can be taken to the field, where identification of the substance used is vital. Comparative spectra will be assembled and committed to compact disks (CDs) or memory chips that will form an integral part of the system and permit instant identification. If miniaturization is successfully achieved, the combined analytical power of gas chromatography coupled with mass spectrometry will provide a remarkably versatile capability.

- Very high sensitivity light detection and ranging (LIDAR), which will be able to discriminate the vapor associated with clouds or ground deposition, will be developed. Using UAVs, also equipped with GPS receivers and ground-scanning radar, the system will provide a field commander with a capability for instantaneous terrain contamination mapping. A hand-held or vehicle-mounted version of the airborne system will be available for use by either military or civilian personnel for rapid contamination mapping in instances of terrorist attacks.

- Miniaturization will permit either double- or multiple-probe capabilities. Such systems will sample selectively after the initial probe has been saturated and provide field instruments that will switch to secondary and tertiary probes upon sensing overload on initial probes. The systems will automatically begin purging the saturated probes so that a detection capability will always be available.

- The merging of analytical chemistry techniques, often called "hyphenation," usually improves the quality of analytical results. The possible merging of technologies such as SAW with ion mobility spectrometry (IMS) and/or infrared (IR) or other combinations would result in enhanced detection systems. With the miniaturization of systems and techniques, such as sensor data fusion, pattern recognition, neural networks, and high power lasers, "hyphenation" of detection techniques will certainly become an important aspect of chemical detection.

For more complete battlefield management, the ongoing results from all sensors will be electronically transmitted to a computer at brigade level that integrates the results with terrain maps and meteorological data to provide an instantaneous picture, and warning where required, of any chemical attack or contamination on the battlefield.

RATIONALE

Joint Vision 2010 describes the four operational concepts that will be developed for the future: dominant maneuver, precision engagement, full-dimensional protection, and focused logistics. New sensors that "…will be deployed to detect chemical or biological attack at great ranges and provide warning to specific units that may be affected" are part of the *Joint Vision 2010* concept of full-dimensional protection. It is clear that U.S. forces must be prepared to wage war in an environment that includes the use of weapons of mass destruction (WMD).

It is expected that some of the "new" types of agents mentioned in subsection 5.3 will be solids, making them very difficult to detect with current techniques. All current analytical methodologies require the sample to be in the gaseous state when presented to the detection transducer. Normally, for any of the current techniques to be applicable to detection of solids, vaporization of the solid has to occur. This requires heat to be applied locally and thus precludes remote detection. As a future development, it is conceivable that the sample could be tested by a surface light spectroscopic technique such as resonance Raman spectroscopy. In this case the sample need not be vaporized since the Raman spectrum can be generated from the surface scatter. Because the Raman spectrum is akin to IR spectra, some degree of specificity can be accomplished. Lasers can also be used to vaporize extremely small samples of a solid deposit, while laser spectroscopic methods could be employed to analyze the miniature vapor cloud.

WORLDWIDE TECHNOLOGY ASSESSMENT

Detection is an area where active development is occurring throughout the world for a multitude of reasons. Because this technology is rarely classified or limited for other than commercial purposes, the spread of new detection technology is expected to be rapid and worldwide.

In the UK, the DERA (Defence Evaluation and Research Agency) staff at Porton Down has been at the leading edge of chemical and biological defense. Projects exist in the following research areas: chemical and biological detection, aerosol science, ion chemistry, rheology, gene probes, sensor technology, and microelectronics. Graseby Dynamics (UK) is one of the world leaders in detection technologies. The company maintains a substantial investment in R&D, with multidisciplinary skills spanning the wide range required for the design and development of sensing systems for trace quantities of chemical and biological materials. The following are other countries and companies involved in detection equipment:

- ***Canada***
  - Anachemia, Ca
- ***China***
  - Research Institute of Chemical Defense
- ***France***
  - Giat
  - Proengin SA
- ***Germany***
  - Bruker-Saxonia Analytik GmbH
- ***Finland***
  - Environics OY
- ***Israel***
  - Elbit Limited
- ***Russia***
  - State factories
- ***Sweden***
  - Akers Krutbruk Protection AB
- ***Switzerland***
  - Louis Schlieffer AG
- ***United States***
  - Environmental Technologies Group, Inc. (ETG)
  - Calspan
  - Advanced Technical Products

Several countries produce reconnaissance systems, and mobile detection systems: Bulgaria, Croatia, Czech Republic, France, Germany, Hungary, Japan, South Korea, Romania, Russia, the UK, and the United States. Those involved with command, control, communications and intelligence, which is essential to tying capabilities together, include Denmark, Germany, South Africa, the UK, and the United States.

Country	Detection	Warning	Identification
Australia	●●●●	●●●●	●●●●
Canada	●●●●	●●●●	●●●●
China	●●●	●●●	●●●
Czech Republic	●●●●	●●●●	●●●●
Egypt	●●	●●	●●
Finland	●●●●	●●●●	●●●●
France	●●●●	●●●●	●●●●
Germany	●●●●	●●●●	●●●●
India	●●	●●	●●
Iran	●●	●●	●●
Iraq	●●	●●	●●
Israel	●●●●	●●●●	●●●●
Japan	●●●	●●●●	●●●●
Libya	●●	●●	●●
North Korea	●●	●●	●●●
Pakistan	●●	●●	●●
Poland	●●	●●	●●
Russia	●●●●	●●●●	●●●●
Slovak Republic	●●	●●	●●
South Korea	●●●●	●●●●	●●●●
Sweden	●●●●	●●●●	●●●●
Switzerland	●●●●	●●●●	●●●●
Syria	●●	●●	●●
UK	●●●●	●●●●	●●●●
United States	●●●●	●●●●	●●●●

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Figure 5.4-1. Chemical Detection, Warning, and Identification WTA Summary

LIST OF TECHNOLOGY DATA SHEETS
III-5.4. CHEMICAL DETECTION, WARNING, AND IDENTIFICATION

DATA SHEET III-5.4. ION MOBILITY SPECTROMETRY (IMS)

Developing Critical Technology Parameter	Hand-held, lightweight Sensitivity at <1 μg/m^3 for nerve agents with sample preconcentration, <1 mg/m^3 for blister agents. Sensitivity at 0.1 mg/m^3 for nerve agents in <1 sec, <20 mg/m^3 for blood agents.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Pattern recognition.
Technical Issues	Data bases. Computational capability. Detection of low vapor pressure or solid agents. Solid samples.
Major Commercial Applications	Environmental monitoring. Process control. Contraband detection. Fire sensor (IMS using variable field strength).
Affordability	Moderately expensive.

RATIONALE

IMS systems such as the chemical agent monitor (CAM) offer the capability of point detection of general classes of agent in the field and ascertaining if decontamination has been effective. This is normally accomplished using a radioactive source to ionize chemical substances drawn into the instrument and measuring the time it takes the particular ionized particle to traverse a drift tube and register on a detector. Each ion type has a characteristic mobility time and can be measured semiquantitatively. Although the technique directly measures the material in the air drawn into the system, it is affected by the humidity, temperature, and composition of the substances in the air. Because the technique looks at a generic part of the molecule it is subject to false positives. IMS instruments can theoretically be of high sensitivity and, if combined with a different sensor type, could be a tool for determining specificity to a high probability for the agent or agents involved.

In the future, U.S. forces will have a greater need to detect toxic chemicals in the field because of the increased possibility of the use of chemical weapons against them. Detection technologies fall under the *Joint Vision 2010* concept of full-dimensional protection. Hand-held equipment with increased sensitivity is essential to identifying chemcial agents and ensuring that proper protection is taken. IMS is not a new technology, but computational capability will allow miniaturization and application in a hand-held device.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●●	France	●●●●	Germany	●●●●
Hungary	●●●	India	●●	Iran	●●	Iraq	●●
Israel	●●●●	Japan	●●●	Libya	●●	North Korea	●●
Pakistan	●●	Poland	●●	Russia	●●●●	Slovak Republic	●●
South Korea	●●●●	Sweden	●●●●	Switzerland	●●●	Syria	●●
UK	●●●●	United States	●●●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

The development of small IMS devices is being spearheaded by the military. The following countries produce detectors that use IMS:

- ***Canada***
  - Defence Research Establishment

- ***Finland***
  - Environics OY
- ***Germany***
  - Bruker-Saxonia Analytik GmbH
- ***Russia***
  - State factories
- ***UK***
  - Graseby

Hungary has the GVJ-2, which uses IMS, under development.

DATA SHEET III-5.4. MASS SPECTROMETRY (MS)

Developing Critical Technology Parameter	Miniaturization (field-portable units) especially for peripheral equipment; one-man portable; ability to ruggedize.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Pattern recognition.
Technical Issues	Data bases. Computational capability. Mutivariate data models to enhance ion identification.
Major Commercial Applications	Environmental monitoring. Process control. Contraband detection. Analytical chemistry.
Affordability	Expensive.

RATIONALE

MS uses an ionizing source to split the measured molecules into a number of charged components. These are measured on a detector as a characteristic spectra and compared with known spectra of substances of interest (e.g., chemical agents). The spectra, when combined with another detection tool, can result in a high sensitivity and a probability of specificity. It does, however, rely on a previously generated spectral library.

This technology, which can be used to detect toxic chemicals in the field, addresses the concept of full-dimensional protection in *Joint Vision 2010*.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●●	France	●●●●	Germany	●●●●
India	●●	Iran	●●	Iraq	●●	Israel	●●●●
Japan	●●●	Libya	●●	North Korea	●●	Pakistan	●●
Poland	●●	Russia	●●●●	Slovak Republic	●●	South Korea	●●●●
Sweden	●●●●	Switzerland	●●●	Syria	●●	UK	●●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Most development is being accomplished within the military. The German company Bruker-Frazen Analytik GmbH produces a detector (MM-1) that uses MS. In France, MGP Instruments is developing the DAXEL analyzer, which uses MS-MS.

DATA SHEET III-5.4. GAS CHROMATOGRAPHY (GC)-ION MOBILITY SPECTROMETRY (IMS)

Developing Critical Technology Parameter	Low power consumption GC. Smaller, shorter, faster GC columns. Sensitivity at <1 µg/m^3 for nerve agents, <1 mg/m^3 for blister.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Pattern recognition. Multivariate data models.
Technical Issues	Data bases. Computational capability.
Major Commercial Applications	Environmental monitoring; process monitoring; pesticide analysis; leak detection; stack monitoring; worker exposure determination; quality assurance and quality control; food industry for use as an "electronic" nose.
Affordability	Moderately expensive.

RATIONALE

The combination of GC with IMS will provide partial identification of low levels of chemicals in the field, provided GC and IMS spectra are available.

This detection technology addresses the need to detect toxic chemicals in the field. Full-dimensional protection in *Joint Vision 2010* includes the ability to detect the chemical agents to enable forces to take protective measures.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●●	France	●●●●	Germany	●●●●
India	●●	Iran	●●	Iraq	●●	Israel	●●●●
Japan	●●●	Libya	●●	North Korea	●●	Pakistan	●●
Poland	●●	Russia	●●●●	Slovak Republic	●●	South Korea	●●●●
Sweden	●●●●	Switzerland	●●●	Syria	●●	UK	●●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

FemtoScan Corporation has developed what is reported to be the first commercial GC/IMS instrument for process and field applications. Based on IMS technology for ultrasensitive detection of gas-phase analytes with high-speed automated vapor sampling (AVS), the instrument uses transfer line gas chromatography (TLGC) sampling and separation capabilities developed by FemtoScan and the University of Utah (www.utah.edu./marc/ homepage.htm). The device is a sensitive and selective, near-real-time vapor detector. IDS, Intelligent Detection Systems Inc. (CA), has a proprietary chemical trace detection technology—a combination of GC and IMS (GC/IMS)—which is a sophisticated chemical analysis tool that can detect minute molecules and vapors of the chemicals associated with drugs and explosives. Orbital Sciences is developing the GC/IMS-Chemical Agent Detector (GI-CAD). The UK (Graseby Ionics Division) produces an environmental vapor monitor (EVM) that combines gas chromatography and IMS technologies.

DATA SHEET III-5.4. GAS CHROMOTAGRAPHY (GC)-MASS SPECTROMETRY (MS)

Developing Critical Technology Parameter	Lower power consumption GC. Smaller, shorter, faster GC columns. One-man portable. Ruggedization.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Pattern recognition.
Technical Issues	Data bases, computational capability; miniaturization of ancillary equipment.
Major Commercial Applications	Environmental monitoring. Process control. Field analysis. Analytical chemistry.
Affordability	Expensive.

RATIONALE

The combination of GC with MS allows the detectors to measure compounds that have eluted from gas chromatograph column at specific elution. The combination of recorded and compared spectra and GC elution temperature provides a high probability of specific identification of a substance.

There is a need to detect toxic chemicals in the field. Full-dimensional protection dictates the capability to identify the use of toxic chemical agents. "Fast" GCs exist, but size and power consumption are issues. The airport security swipes of hand-carried luggage is an example of fast GC analysis.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●●	France	●●●●	Germany	●●●●
India	●●	Iran	●●	Iraq	●●	Israel	●●●●
Japan	●●●	Libya	●●	North Korea	●●	Pakistan	●●
Poland	●●	Russia	●●●●	Slovak Republic	●●	South Korea	●●●●
Sweden	●●●●	Switzerland	●●●	Syria	●●	UK	●●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Germany (Bruker-Franzen Analytik GmbH) has developed a detector that uses GC-MS. In the United States, Viking Equipment has assembled a detector that also employs GC-MS. Shimadzu (a multinational company founded in Japan) introduced a GC-MS device in 1992 that can be used for forensic analyses, drug testing, environmental monitoring, component identification, and product impurity identification. Efforts continue to improve this instrument.

DATA SHEET III-5.4. SURFACE ACOUSTIC WAVE (SAW)

Developing Critical Technology Parameter	New coatings to interact with target materials. Sensitivity at <1 µg/m^3 for nerve agents with sample pre-concentration; <0.1 mg/m^3 in <1 minute for nerve agents, <1 mg/m^3 for blister agents.
Critical Materials	New coating materials.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Pattern recognition, neural networks.
Technical Issues	Signal-processing algorithms to decrease response times (10–15 sec, depends on concentration); computational capability; miniaturization of ancillary systems supporting SAW operation. Making the process readily reusable. Specialty chemicals for polymer development that can be used for coating the SAW device.
Major Commercial Applications	Monitoring hazardous chemical vapors, potential fires and environmental pollutants.
Affordability	At present, moderately expensive.

RATIONALE

SAW is believed to be a technology that could result in an individual point alarm for the soldier or civilian first responder. Although false positives would remain a potential problem, the system could prove extremely useful in surveying suspected contaminated environments. System detection limits for SAW are in the parts per trillion area. The system operates autonomously with a simple gas sampling system and without the need for support gases. Individual SAW devices operate by generating surface mechanical oscillations in piezoelectric quartz with frequencies in the megahertz range. Coating the SAW devices with different polymeric materials that selectively absorb different gases allows gas detection by changes in SAW frequency. Arrays of polymer-coated SAW devices detect different gases, and pattern-recognition techniques interpret data and identify unknowns.

This technology responds to the need to detect toxic chemicals in the field. It addresses the concept of full-dimensional protection embodied in *Joint Vision 2010*.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●●	France	●●●●	Germany	●●●●
India	●●	Iran	●●	Iraq	●●	Israel	●●●●
Japan	●●●	Libya	●●	North Korea	●●	Pakistan	●●
Poland	●●	Russia	●●●●	Slovak Republic	●●	South Korea	●●●●
Sweden	●●●●	Switzerland	●●●	Syria	●●	UK	●●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

At the Prins Maurits Laboratory TNO, work on SAW chemical sensors is being performed. The main subjects have been implementation of SAW technology on a silicon chip, the development of a SAW sensor for NO_2, and the development of a SAW sensor for chemical warfare agents.

DATA SHEET III-5.4. FIELD ION SPECTROMETRY (FIS)

Developing Critical Technology Parameter	Improved selectivity by separating compounds. Improved scientific understanding. Able to analyze subparts per million and in some cases subparts per billion.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Pattern recognition.
Technical Issues	Immature—many unknowns, e.g., theoretical modeling; interaction of radio frequency with IMS. Ruggedization. Databases. Analyzes gas or vapors and solids if they are vaporizable [it is possible that a small yttrium aluminum garnet (YAG) laser could be incorporated in this technology to serve as a plasma generator with a focused beam to produce an ion sample from solids].
Major Commercial Applications	Environmental monitoring. Contraband detection. Fire sensing.
Affordability	$20,000 for a single component analyzer, plus an additional $1,000 per extra component.

RATIONALE

FIS is a new technology (less than 5 years old) that has been developed for trace detection of narcotics, explosives, and chemical warfare agents. This technology incorporates a unique ion filter using dual transverse fields, which allows interferences to be electronically eliminated without the use of GC columns, membranes, or other physical separation methods.

FIS is related to IMS in that it is a technique for separating and quantifying ions while they are carried in a gas at atmospheric pressure. In addition, both methods use soft ionization methods that yield spectra in which the species of interest produce the main features.

The sensor has no moving parts except for a small recirculation fan and no consumables except for the replaceable calibrator and gas purification filters. The size of the instrument is 0.8 ft^3 excluding a computer for control and display. The sole manufacturer of the FIS has reported limits of detection in the low picograms for common explosives such as RDX, PETN, and TNT. In addition, a response time of 2 sec for a single component and approximately 5 sec for each additional component is advertised. To date, there are no independent test data available for the FIS.

The instrument's estimated selling price is $20,000 for a single component analyzer, plus an additional $1,000 per extra component.

WORLDWIDE TECHNOLOGY ASSESSMENT

Canada ●●● United States ●●●●

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Mine Safety Appliances Company (U.S.) is the only known U.S. company considering FIS.

The Institute for National Measurement Standards (CA) is offering a mass spectroscopic detection system for FIS (R. Guevremont, R. Purves, C. Pipich) as a business opportunity.

DATA SHEET III-5.4. GAS PHASE ION CHEMISTRY

Developing Critical Technology Parameter	Improved ion sources (nonradioactive) for complex matrices, e.g., soil and water samples.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Unknown, perhaps pattern recognition if coupled with traditional specroscopy.
Technical Issues	Product separation, data, kinetic mechanisms. Ruggedization.
Major Commercial Applications	Soil and water monitoring. Analytical chemistry. Environmental monitoring.
Affordability	Moderately expensive.

RATIONALE

There is a need to provide a sampling and preparation technique to generate a gas phase sample from complex soil and water sources that then can be measured by some of the techniques previously mentioned.

Increasingly there is a need to detect toxic chemicals in the field. Full-dimensional protection in *Joint Vision 2010* can be construed to include force protection off the battlefield as well as on it.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●●	France	●●●●	Germany	●●●●
India	●●	Iran	●●	Iraq	●●	Israel	●●●●
Japan	●●●	Libya	●●	North Korea	●●	Pakistan	●●
Poland	●●	Russia	●●●●	Slovak Republic	●●	South Korea	●●●●
Sweden	●●●●	Switzerland	●●●	Syria	●●	UK	●●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Commercial requirements drive this technology. Work is ongoing throughout the world.

DATA SHEET III-5.4. PASSIVE INFRARED (IR)

Developing Critical Technology Parameter	Faster signal processing (terabytes/sec). Smaller, faster systems.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Pattern recognition.
Technical Issues	Obscurants; subtraction of background; optics; cooling.
Major Commercial Applications	Environmental monitoring.
Affordability	Expensive.

RATIONALE

IR detection measures the characteristic absorption bands for a gaseous substance. By ascertaining the wavelength and strength of these bands, vapors can be detected and partially analyzed or identified.

Standoff detection is needed to detect the use of chemical weapons and enable forces to avoid contamination. As part of full-dimensional protection espoused in *Joint Vision 2010*, standoff capabilities are a necessity. There is also a potential to use passive IR detection for land mine detection.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●●	France	●●●●	Germany	●●●●
Hungary	●●●	India	●●	Iran	●●	Iraq	●●
Israel	●●●●	Japan	●●●	Libya	●●	North Korea	●●
Pakistan	●●	Poland	●●	Russia	●●●●	Slovak Republic	●●
South Korea	●●●●	Sweden	●●●●	Switzerland	●●●	Syria	●●
UK	●●●●	United States	●●●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

The United States developed the M21 remote sensing chemical agent alarm (RSCAAL), which uses a passive IR sensor. Hungary is developing a passive IR detector, too.

DATA SHEET III-5.4. ABSORPTION LIDAR

Developing Critical Technology Parameter	Backpack system; gigabytes/sec processing speed. Increased sensitivity to detect low level vapor concentrations in aerosol clouds.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Pattern recognition.
Technical Issues	Obscurants. Smaller, better, more powerful. Tunable lasers.
Major Commercial Applications	Environmental monitoring.
Affordability	Expensive.

RATIONALE

LIDAR measures the composition of a cloud by firing a laser or lasers into a cloud and measuring the characteristic absorption or backscatter from the vapor components. When the clouds consist of particulates of low volatility (for example, VX droplets), LIDAR is ineffective. In the future, however, it may also be possible to aim a LIDAR at surfaces to identify deposited substances, whether solid or liquid.

Technology may provide possible standoff detection of low volatility clouds which could not be detected by current IR detectors. Military applications for atmospheric trace gas sensing include remote detection of industrial emissions (particularly as they pertain to nuclear weapons treaty verification and illicit drug manufacturing), identification and targeting of mobile rocket launch facilities, identification of underground or concealed bunkers and warehouses, the detection and identification of chemical warfare agents, and remote sensing of emissions from ballistic missiles and low observable aircraft.

There is a need for standoff detection as part of the *Joint Vison 2010* concept of full-dimensional protection.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●●	France	●●●●	Germany	●●●●
India	●●	Iran	●●	Iraq	●●	Israel	●●●●
Japan	●●●	Libya	●●	North Korea	●●	Pakistan	●●
Poland	●●	Russia	●●●●	Slovak Republic	●●	South Korea	●●●●
Sweden	●●●●	Switzerland	●●●	Syria	●●	UK	●●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

The military is leading this effort although it could be used for environmental monitoring. The Czech Military Technical Institute of Protection, Brno, developed a differential absorption LIDAR (DIAL) detector, but it is complicated to operate and prohibitively expensive to produce. In France, the Centre d'Études du Bouchet (CEB) and Compagnie Industrielle des Lasers (CILAS) conduct research in absorption LIDAR. THOMSON–TRT Defence is developing the SYDERAL chemical threat warning and identification system.

DATA SHEET III-5.4. SPECTROSCOPY [ELECTRO-OPTICAL (E-O) PROPERTIES]

Developing Critical Technology Parameter	Remove spectrum gaps for solid, liquid, and gas phases. Establishing a surface-enhanced resonance Raman spectroscopic signature.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	None identified.
Technical Issues	Eye safety under operational environment. Sources, detectors, analysis of spectra.
Major Commercial Applications	Environmental monitoring.
Affordability	Not an issue.

RATIONALE

Spectroscopy is the next generation of detection technology. Spectroscopy would enable detection of CW and BW simultaneously. It would help to provide for full-dimensional protection as envisioned in *Joint Vision 2010*.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●●	France	●●●●	Germany	●●●●
India	●●	Iran	●●	Iraq	●●	Israel	●●●●
Japan	●●●	Libya	●●	North Korea	●●	Pakistan	●●
Poland	●●	Russia	●●●●	Slovak Republic	●●	South Korea	●●●●
Sweden	●●●●	Switzerland	●●●	Syria	●●	UK	●●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

The military is spearheading the development of this technology, although it could find use in environmental monitoring.

DATA SHEET III-5.4. SAMPLE COLLECTION

Developing Critical Technology Parameter	Aerosols and particulates—air, liquids, solids—surfaces. Increased sensitivity; reduced bias.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	None identified.
Technical Issues	Materials compatibility.
Major Commercial Applications	Environmental monitoring. Process control.
Affordability	Not an issue.

RATIONALE

Effective and accurate means of identifying materials and determining their concentrations are highly dependent upon accurate and reproducible sampling procedures. It has long been recognized that different methodologies give different results. If results are to be used to pronounce an area safe and fit for unprotected habitation or for evidence in the instance of criminal terrorism, it is important that they be scientifically valid and reproducible. This will require establishing and validating procedures to be applied across a broad spectra of chemical compounds and different physical states.

Sample collection supports full-dimensional protection in *Joint Vision 2010.*

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●●	Canada	●●●●	China	●●●	Czech Republic	●●
Egypt	●●	Finland	●●●●	France	●●●●	Germany	●●●●
India	●●	Iran	●●	Iraq	●●	Israel	●●●●
Japan	●●●	Libya	●●	North Korea	●●	Pakistan	●●
Poland	●●	Russia	●●●●	Slovak Republic	●●	South Korea	●●●●
Sweden	●●●●	Switzerland	●●●	Syria	●●	UK	●●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

R&D on ways to improve sample collection is accomplished throughout the world.

SECTION 5.5—OBSCURANTS

Highlights

- If used properly, obscurants can negate the value of high-technology reconnaissance, target acquisition, and precision-guided munition systems
- Obscurant R&D, which resumed in 1972, is still being well funded in many countries.
- The effectiveness of technologies used in U.S. military systems can be degraded with obscurants at a fraction of the cost of the U.S. technologies.
- Historically, employment of obscurants has not been complex.

OVERVIEW

This subsection covers obscurants, materials that degrade or defeat sensors that operate in any part of the electromagnetic spectrum. An obscurant is defined as:

- Any gas, liquid, or solid particle, either man-made or natural, suspended in the atmosphere that affects any part of the electromagnetic spectrum by:
  - Scattering
  - Absorption
  - Radiance
  - Reflection, or
  - Refraction.

Obscurants are identified by their application in the various parts of the electromagnetic spectrum: visible, visible and near-IR, visible through far-IR, mid- and far-IR, millimeter wave (MMW), centimeter wave (CMW), visible and MMW, visible and CMW, visible through millimeter wave, MMW, and CMW.

RATIONALE

Smoke has been around since man discovered fire. The methodical, planned use of smoke in battle, however, was a development of World War I. At the end of that war research in smoke was emphasized in many countries. During World War II the Soviet Union and the United States used smoke extensively. After the war, interest in smoke declined because most countries believed that the new sensors coming into the field could easily penetrate smoke clouds. It was thought that in spite of the success of smoke in World War II, practical limits in screening capabilities had been reached.

In 1959 the Poles showed that by combining different World War II obscurants, a new combination obscurant that was effective against the then-fielded sensors, including radar, could be created. However, real interest in obscurants did not reawaken until after the 1973 Arab-Israeli War. During that war it was shown that antitank weapons were very effective and that obscurants, if employed correctly, could seriously degrade, and in many cases defeat, these weapons. By the mid 1980’s, however, funding for obscurant research again declined, with only a few Warsaw Pact countries continuing research. Attitudes changed again during Desert Storm.

The world saw the effectiveness of the fielded “smart” munitions on television and was impressed. Many countries reevaluated the target acquisition, reconnaissance, and precision-weapon threats to themselves. As a result of their analyses, these countries began looking for countermeasures, including obscurants. Consequently, countries with an obscurant R&D capability began to fund such research again. Countries without R&D capability started buying new obscurant dissemination systems and agents to fill their needs. In many cases, this led R&D-capable countries to expand their efforts even further.

Obscurants enjoy a number of advantages over other countermeasures:

- They are less expensive to produce and therefore less expensive to buy.
- Individuals employing obscurant systems require virtually no special knowledge or skill; training can be accomplished in very little time.
- Except for large smoke generators, obscurant-disseminating systems require little maintenance.
- There are no sanctions against these countermeasures. Any country can buy them with no restrictions.

Research on obscurants has resulted in upgrading World War II disseminating systems and agents to make them more effective on today's battlefield. Theory and testing have shown that with changes in the geometry and conductivity of these materials, they are effective in a wide range of wavebands. By employing these agents using the correct doctrine, an obscurant that is normally effective in only the visible and near-IR wavebands can be made effective in the visible through the far-IR wavebands. Research on upgrading World War II conventional chaff by using microfibers is also being conducted. Other research is being done on plates of different geometries, cylinders, and nanometer-sized particles. Research on charged vs. neutral particles is being conducted to determine if one has a decided advantage over the other. Commercial research on dissipating fog for civil aviation has military application.

WORLDWIDE TECHNOLOGY ASSESSMENT

Although the United States has devoted some resources to obscurants, foreign countries have more motivation to develop new obscurants and new disseminating systems that will either seriously degrade or defeat technologically advanced U.S. sensors for reconnaissance, surveillance, target acquisition, and precision-guided munitions.

Country	Visible and Near IR	Visible thru Far IR	Mid and Far IR	MMW	CMW	Visible thru CMW
Australia	●●●	●●●	●●●	●●	●●	●
Canada	●●●	●●●	●●●	●●	●●	●
China	●●●●	●●●●	●●●●	●●●●	●●●●	●●●
Czech Republic	●●●	●●●	●●●	●	●	●
Egypt	●●●	●●●	●●	●	●	●
France	●●●●	●●●●	●●●●	●●●	●●●	●●●
Germany	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
India	●●●●	●●●●	●●●●	●●●	●●●	●●●
Iran	●●●●	●●●●	●●●●	●●●●	●●	●●
Iraq	●●●	●●	●●	●	●	●
Israel	●●●●	●●●●	●●●●	●●	●●	●●
Italy	●●●	●●●	●●●	●●	●●	●●
Japan	●●●●	●●●●	●●●●	●●●	●●●	●●●
North Korea	●●●●	●●●●	●●●●	●●	●●	●●
Pakistan	●●●●	●●●●	●●●●	●	●	●
Poland	●●●●	●●●●	●●●●	●●	●●	●●
Russia	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Slovak Republic	●●●●	●●●●	●●●●	●●	●●	●
South Africa	●●●●	●●●●	●●●	●●●	●●	●●●
South Korea	●●●●	●●●●	●●●●	●●	●●	●●
Spain	●●●●	●●●●	●●●●	●●	●●	●
Sweden	●●●●	●●●●	●●●●	●●	●●	●
Switzerland	●●●●	●●●●	●●●●	●●●	●●●	●●
Syria	●●●●	●●●●	●●●●	●●	●●	●●
UK	●●●●	●●●●	●●●●	●●●	●●	●●
United States	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Figure 5.5-1. Obscurants WTA Summary

LIST OF TECHNOLOGY DATA SHEETS
III-5.5 OBSCURANTS

DATA SHEET III-5.5. MILLIMETER WAVE—SCATTERING AND ABSORBING

Developing Critical Technology Parameter	Packing density >75% of the material density; dissemination efficiency for large area systems >80% and for projected systems >50%; Ext_{mm} significantly greater than 2.
Critical Materials	Metal microwires; metal-coated fibers.
Unique Test, Production, Inspection Equipment	Aerosol test chambers; transmissometers; test ranges; nephelometers.
Unique Software	Obscurant modeling; transport and diffusion.
Technical Issues	Reduction of logistics burden, toxicity, re-aerosolization. Employment of obscurants is not complex.
Major Commercial Applications	Ram for high structures, electronics.
Affordability	Inexpensive, especially in relation to the assets that are protected. Also a very cost-effective means for an adversary to negate precision weapons systems.

RATIONALE

Obscurants across the electromagnetic spectrum protect limited and expensive assets from observation and targeting. They counter enemy reconnaissance, surveillance, and target acquisition (RSTA) capabilities. Obscurants can also be used for signaling, deception, and other uses. Radar and thermal homing sensors operate in the millimeter wave band and can therefore be degraded with obscurants that affect that wavelength.

Joint Vision 2010 includes full-dimensional protection as one of four operational concepts for the future. Although not explicitly stated, degrading enemy RSTA that employs new technologies should be considered to be a component of this concept. Advanced technologies in the hands of an adversary will increase the importance of protection at all echelons.

Note that increased reliance on precision capability by the United States and its allies will increase interest in obscurants by potential adversaries.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●	Bulgaria	●●	Canada	●●●	China	●●
Czech Republic	●●●	Denmark	●●●	Egypt	●●	Finland	●●●
France	●●●	Germany	●●●	Hungary	●●●	India	●●
Iran	●●	Iraq	●●	Israel	●●●	Italy	●●●
Japan	●●●●	Libya	●●	Netherlands	●●●	North Korea	●●
Norway	●●●	Pakistan	●●	Poland	●●	Russia	●●●●
Slovak Republic	●●●	South Africa	●●	South Korea	●●	Spain	●●●
Sweden	●●●	Switzerland	●●●	Syria	●●	UK	●●●
United States	●●●●	Vietnam	●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

A number of countries have increased their work on obscurants since Operation Desert Storm. The United States has some work underway, but funding is needed to see it to fruition.

DATA SHEET III-5.5. MID AND FAR INFRARED—RADIANCE

Developing Critical Technology Parameter	Emissive obscurant effectiveness parameters; methods for direct comparison with enemy smoke effectiveness.
Critical Materials	Activated metals; reactive metals; pyrophoric materials.
Unique Test, Production, Inspection Equipment	Field instrumentation; production quality control; aerosol test chambers; transmissometers; test ranges; nephelometers.
Unique Software	Obscurant modeling (new models required).
Technical Issues	Increasing the radiance at correct wavelength; reduction of logistics burden; toxicity. Survivability mensuration.
Major Commercial Applications	None identified.
Affordability	Inexpensive, especially in relation to the assets that are protected. Also a very cost-effective means for an adversary to negate precision weapons systems.

RATIONALE

Obscurants across the electromagnetic spectrum protect limited and expensive assets from observation and targeting. They counter enemy reconnaissance, surveillance, and target-acquisition capabilities. Mid- and far-IR radiance obscurants can also be used for signaling, deception, IR decoy, and other uses. Laser range finders, laser designators, thermal imagers, and thermal homing sensors operate in the mid–far IR band and therefore can be degraded by obscurants in those wavelengths.

Joint Vision 2010 includes full-dimensional protection as one of four operational concepts for the future. Although not explicitly stated, degrading enemy RSTA that employs new technologies should be considered to be a component of this concept. Advanced technologies in the hands of an adversary will increase the importance of protection at all echelons.

It should also be noted that increased reliance on precision capability by the United States and its allies will increase interest in obscurants by potential adversaries.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●	Bulgaria	●●	Canada	●●●	China	●●
Czech Republic	●●●	Denmark	●●●	Egypt	●●	Finland	●●●●
France	●●●●	Germany	●●●●	Hungary	●●●	India	●●
Iran	●●	Iraq	●●	Israel	●●●	Italy	●●●
Japan	●●●	Netherlands	●●●	North Korea	●●	Norway	●●●●
Pakistan	●●	Poland	●●	Russia	●●●●	South Africa	●●
South Korea	●●	Sweden	●●●●	Switzerland	●●●	Syria	●●
UK	●●●●	United States	●●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

A number of countries have increased their work on obscurants since Operation Desert Storm. The United States has some work underway, but funding is needed to see it to fruition.

DATA SHEET III-5.5. MULTISPECTRAL (VISIBLE, INFRARED, MILLIMETER, AND POSSIBLY CENTIMETER)

Developing Critical Technology Parameter	Packing density >50% of source density; dissemination efficiency >50%; extinction coefficient >2.
Critical Materials	Conductive fibers or a mixture of materials that are used for the various wavelengths.
Unique Test, Production, Inspection Equipment	Field instrumentation; obscurant modeling; production quality control; aerosol test chambers; transmissometers; test ranges; nephelometers.
Unique Software	Obscurant modeling.
Technical Issues	Reduction of logistics burden, toxicity, reaerosolization.
Major Commercial Applications	None identified.
Affordability	Inexpensive, especially in relation to the assets that are protected. Also a very cost-effective means for an adversary to negate precision weapons systems.

RATIONALE

Obscurants across the electromagnetic spectrum protect limited and expensive assets from observation and targeting. They counter enemy reconnaissance, surveillance, and target acquisition capabilities. Obscurants can also be used for signaling, deception and other uses.

Joint Vision 2010 includes full-dimensional protection as one of four operational concepts for the future. Although not explicitly stated, degrading enemy RSTA that employs new technologies will be an important component of this concept. Advanced technologies in the hands of an adversary will increase the importance of protection at all echelons.

It should also be noted that increased reliance on precision capability by the United States and its allies will increase interest in obscurants by potential adversaries.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●	Canada	●●●	China	●●	Czech Republic	●●●
Egypt	●●	France	●●●	Germany	●●●	Hungary	●●●
India	●●	Iran	●●	Iraq	●●	Israel	●●●
Japan	●●●●	North Korea	●●	Norway	●●●	Pakistan	●●
Poland	●●	Russia	●●●●	Slovak Republic	●●●	South Africa	●●●
South Korea	●●●	Spain	●●●	Switzerland	●●●	Syria	●●●
UK	●●●	United States	●●●●	Vietnam	●●		

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

A number of countries have increased their work on obscurants since Operation Desert Storm. The United States has some work underway, but funding is needed to see it to fruition.

DATA SHEET III-5.5. SPECTRAL DIRECTION SELECTIVITY

Developing Critical Technology Parameter	Limit screening to specific regions of the spectra.
Critical Materials	Specially controlled sizes and shapes of conductive and semiconductive particles or techniques for polarization of an obscurant cloud.
Unique Test, Production, Inspection Equipment	Aerosol test chambers; transmissometers; test ranges; nephelometers.
Unique Software	Battle modeling.
Technical Issues	Effectiveness and maintenance of cloud polarization.
Major Commercial Applications	None identified.
Affordability	Not an issue.

RATIONALE

Spectral direction selectivity would theoretically allow "friendly" troops equipped with the correct instrumentation to look "through" their own obscurant cloud. If screens were able to be deployed in designated regions of the electromagnetic spectrum, U.S. forces would be able to use sensors in other portions of the spectrum for military systems.

WORLDWIDE TECHNOLOGY ASSESSMENT

Canada	●●	China	●●	Egypt	●●	France	●●
Germany	●●	India	●●	Iran	●●	Iraq	●●
Israel	●●●	Japan	●●●●	Netherlands	●●	North Korea	●●
Norway	●●	Pakistan	●●	Poland	●●	Russia	●●●●
South Africa	●●	South Korea	●●	Syria	●●●	UK	●●●
United States	●●●●	Vietnam	●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

A number of countries have increased their work on obscurants since Operation Desert Storm. The United States has some work under,way but funding is needed to see it to fruition.

DATA SHEET III-5.5. TEMPORAL SELECTIVITY

Developing Critical Technology Parameter	Precisely select amount of time (e.g., 5 minutes or 5 days).
Critical Materials	Irradiated clouds; using slow heating which would allow selection of screening times in the infrared; degrading coatings.
Unique Test, Production, Inspection Equipment	Aerosol test chambers, transmissometers, test ranges, nephelometers.
Unique Software	None identified.
Technical Issues	Past attempts at using red phosphorus in this capacity have met with limited success.
Major Commercial Applications	None identified.
Affordability	Not an issue.

RATIONALE

Being able to select the precise amount of time that an obscurant would be employed would give a tactical edge to the employing party. Only that force would know how long the obscurant would be used, and the attacker would be forced to wait until the obscuration had dissipated. Protecting forces would fall under *Joint Vision 2010*'s concept of full-dimensional protection.

WORLDWIDE TECHNOLOGY ASSESSMENT

Canada	●●	China	●●	Egypt	●●	France	●●●
Germany	●●	India	●●	Iran	●●	Iraq	●●
Israel	●●	Japan	●●●	North Korea	●●	Pakistan	●●
Poland	●●	Russia	●●●	South Africa	●●	South Korea	●●
Syria	●●●	UK	●●	United States	●●●●	Vietnam	●●

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

A number of countries have increased their work on obscurants since Operation Desert Storm. The United States has some work underway, but funding is needed to see it to fruition.

DATA SHEET III-5.5. ENVIRONMENTAL

Developing Critical Technology Parameter	Signaling and screening obscurants that are environmentally benign, i.e., zero damage to the environment.
Critical Materials	Environmentally benign substance that still provides significant attention-gathering characteristics.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	None identified.
Technical Issues	Cost and complexity of complete environmental evaluation.
Major Commercial Applications	None identified.
Affordability	Not an issue.

RATIONALE

The use of relatively benign signaling smokes and combat obscurants would permit more realistic training in the use and value of battlefield obscurants. Improved training would result in a force being better prepared for actual combat.

WORLDWIDE TECHNOLOGY ASSESSMENT

Canada	●●	China	●●	Egypt	●●	France	●●
Germany	●●●	India	●●	Iran	●●	Iraq	●●
Israel	●●	Italy	●●	Japan	●●●	North Korea	●●
Norway	●●●	Pakistan	●●	Poland	●●	Russia	●●
South Africa	●●	South Korea	●●	Syria	●●●	UK	●●●●
United States	●●●●	Viet Nam	●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

A number of countries have increased their work on obscurants since Operation Desert Storm. The United States has some work underway, but funding is needed to see it to fruition.

DATA SHEET III-5.5. TECHNOLOGY COUPLING

Developing Critical Technology Parameter	Concurrent application of use of obscurants, camouflage, and electronic obfuscation to enhance battlefield operations.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	None identified.
Technical Issues	Potential redundancy and its costs; information introduction.
Major Commercial Applications	None identified.
Affordability	Not an issue.

RATIONALE

The application of multiple technologies has the potential for enhancing each individual effect. Improved battlefield screening could be realized with consequent reductions in combat losses. Although not explicitly included, technology coupling falls within *Joint Vision 2010*'s concept of full-dimensional protection. Technology coupling in this area has been successfully applied previously by U.S. Allies.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●	Bulgaria	●●	Canada	●●	China	●●
Czech Republic	●●	Denmark	●●	Egypt	●●	Finland	●●
France	●●	Germany	●●●●	Hungary	●●	India	●●
Iran	●●	Iraq	●●	Israel	●●	Italy	●●
Japan	●●	Libya	●●	Netherlands	●●	North Korea	●●
Norway	●●	Pakistan	●●	Poland	●●	Russia	●●●
Slovak Republic	●●	South Africa	●●	South Korea	●●	Spain	●●
Sweden	●●	Switzerland	●●	Syria	●●		
UK	●●	United States	●●●	Viet Nam	●●		

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Developments are military both domestic and foreign. A number of countries have increased their work on obscurants since Operation Desert Storm. The United States has some work underway, but funding is needed to see it to fruition.

DATA SHEET III-5.5. PRECISION PARTICLE PRODUCTION

Developing Critical Technology Parameter	Ability to uniformly create specific particle shapes and sizes within a narrow range.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	Particle size and shape distribution measurement.
Unique Software	None identified.
Technical Issues	Quality control of manufacturing techniques and its costs. There is currently no impetus for the precision of control of particle shape and size in industry, so procedural development would be required.
Major Commercial Applications	Paint pigments; microwires; electronics.
Affordability	Reduce logistics burden.

RATIONALE

Control of particle size and shape would allow for more selectivity in the screening performance. Battlefield screening can be better "tuned" to known enemy sensors, reducing the amount of material required and hence the overall logistic burden. Some corporate proprietary data is believed to be involved.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●	Bulgaria	●●	Canada	●●●	China	●●●
Czech Republic	●●●	Denmark	●●●	France	●●●●	Germany	●●●●
India	●●	Iran	●●	Iraq	●●	Israel	●●●●
Japan	●●●●	North Korea	●●	Pakistan	●●	Russia	●●●●
South Africa	●●●	South Korea	●●●	Sweden	●●●●	Syria	●●●
UK	●●●	United States	●●●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Current particulate shaping and sizing techniques are being developed by commercial firms.

DATA SHEET III-5.5. CREATION AND PACKAGING OF NANOMATERIALS

Developing Critical Technology Parameter	Ability to create specific particle shapes with dimensions less than 100 nm.
Critical Materials	Conductive or semiconductive materials that can be made as specifically shaped nano-particles.
Unique Test, Production, Inspection Equipment	Accurate measurement of particle size and shape as well as standardized measurement of extinction coefficient.
Unique Software	None identified.
Technical Issues	The creation, reduction in packaging volume, and dispersion of high length/diameter (l/d) conductive particles. Some development may be required, depending on the nano-particles created to date.
Major Commercial Applications	Catalytic reactions.
Affordability	As the technology develops, costs will decrease.

RATIONALE

The creation of nano-sized particles with diameters between 40 and 70 nm theoretically permits the attainment of extinction coefficients much higher than currently thought possible. This appears to be especially true if the particles are charged. Developing the technology would potentially lead to major reductions in obscurant logistics. Some corporate proprietary data is believed to be involved.

WORLDWIDE TECHNOLOGY ASSESSMENT

Austria	●	France	●●	Germany	●●●●	Italy	●●●
Japan	●●●●	Sweden	●	Switzerland	●●	UK	●●●
United States	●●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Research in nanotechnology exists in varying degrees throughout the industrial world. The main countries involved are the United States, Germany, Japan, the UK, France, Switzerland, Austria, Italy, and Sweden. For a more complete discussion of nano-particle manufacturing, see Section 12.1.

DATA SHEET III-5.5. MEASUREMENT

Developing Critical Technology Parameter	Ability to separately measure in the field location, extent, concentration, path length and extinction coefficient.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	Aerosol test chambers; transmissometers; test ranges; nephelometers.
Unique Software	Data bank related to correlation of measurement techniques and errors of measurement.
Technical Issues	Field measurement is currently limited by vagaries in micrometeorology and accuracy of assessment techniques.
Major Commercial Applications	EPA monitoring; weather monitoring.
Affordability	Not an issue.

RATIONALE

Current techniques permit a field measurement of extinction coefficient only by inference based upon concentration measurements and calculated path length to yield an approximate value. Enhanced measurement would provide a better picture of what is being developed, how it works, and the performance of sensors.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●●	Canada	●●●	China	●●●	Denmark	●●●
France	●●●	Germany	●●●	India	●●	Iran	●●
Iraq	●●	Israel	●●●	Japan	●●●	Netherlands	●●●●
North Korea	●●	Pakistan	●●	Poland	●●	Russia	●●●●
South Africa	●●	South Korea	●●	Sweden	●●●	Syria	●●
UK	●●●	United States	●●●●				

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Countries that endeavor to maximize employment of obscurants require enhanced field measurement techniques.

DATA SHEET III-5.5. PROJECTED OBSCURANTS

Developing Critical Technology Parameter	Ability to project and successfully disseminate infrared and millimeter-wave material.
Critical Materials	Carrier fluids that would greatly decrease or eliminate particle clumping and agglomeration in launch and dissemination environments.
Unique Test, Production, Inspection Equipment	Aerosol test chambers; transmissometers; test ranges; nephelometers.
Unique Software	None identified.
Technical Issues	Fragility of millimeter-wave screening materials.
Major Commercial Applications	None identified.
Affordability	Potentially expensive.

RATIONALE

Currently capabilities exist for IR and millimeter-wave screening only with self-protection smokes and large-area screening smokes. Projected obscurants would “blind” a remotely placed enemy. This would extend their use and open new possibilities for full-dimensional protection as espoused in *Joint Vision 2010*.

WORLDWIDE TECHNOLOGY ASSESSMENT

Australia	●●	Canada	●●	China	●●●	Czech Republic	●●
Egypt	●●	France	●●	Germany	●●	India	●●
Iran	●●	Iraq	●●	Israel	●●	Japan	●●
North Korea	●●	Pakistan	●●	Poland	●●	Russia	●●●
South Africa	●●	South Korea	●●	Syria	●●●	UK	●●●
United States	●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Foreign developments in this area are unknown, although any nation with obscurant capability could be expected to be working on it.

DATA SHEET III-5.5. OBSCURANT CLEARING

Developing Critical Technology Parameter	Ability to use particle subsidence or other methods to create "holes" in obscurant clouds; ability to use energy to create "holes."
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	Aerosol test chambers; transmissometers; test ranges; nephelometers.
Unique Software	None identified.
Technical Issues	Continued movement of the cloud may negate value of "hole" formation.
Major Commercial Applications	Fog clearing at airports.
Affordability	Variable.

RATIONALE

Although total cloud clearing appears logistically infeasible, it may be possible to create selective, albeit relatively short-lived, "holes." This would allow U.S. forces to clear an area that was presumed to be obscured, allowing target acquisition in a "surprise" mode.

WORLDWIDE TECHNOLOGY ASSESSMENT

Canada	●●	China	●●	Denmark	●●	France	●●
Germany	●●	India	●●	Iran	●●	Iraq	●●
Israel	●●●	Japan	●●	North Korea	●●	Pakistan	●●
Poland	●●	Russia	●●●	Syria	●●●	UK	●●●
United States	●●●						

Legend: Extensive R&D ●●●● Significant R&D ●●● Moderate R&D ●● Limited R&D ●

Countries that are subject to having obscurants used against their military forces are most likely to be interested in developing this technology. It would have significant commercial application at airports.